Angora Fire Wildlife Monitoring Project

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Final Report to the South Nevada Public Lands Management Act

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Introduction

Fire is a natural process and the dominant source of disturbance shaping plant and animal communities in mixed conifer forests of the West (Chang, 1996; Skinner and Chang, 1996). Fire creates heterogeneous habitat by changing forest structure and composition (Chang, 1996; Kotliar et al., 2002; Turner et al., 2003), which consequently impacts wildlife communities (Brown and Smith, 2000). While some animals may be negatively impacted by fire, many species across multiple taxa respond positively or neutrally to fire (Brown and Smith, 2000; Fisher and Wilkinson, 2005; Smucker et al., 2005). Composition and abundance of wildlife communities are important indicators of forest health (Cantebury et al., 2000; United States Department of Agriculture, 2004) and biological diversity of native species has significant effects on ecosystem function and services (Hooper et al., 2005; Worm et al., 2006; Duffy, 2009); thus evaluating wildlife response to fire is crucial for effective forest management.

The response of wildlife to fire is varied and dependent on several factors (Hutto, 1995; Kotliar et al., 2002; Smucker et al., 2005). Fire creates patches experiencing varying levels of fire severity, and habitat conditions vary across these patches (Smucker et al., 2005). Low severity fire kills only the most susceptible trees and reduces understory plant biomass, leaving most trees alive, while high severity fire kills most trees and understory plants, drastically modifying existing habitat. Differences in burn severity likely result in different assemblages of wildlife. Species that respond favorably to low severity burns may decline in high severity burns and, conversely, some species may rely upon conditions created by high severity burns (Hutto, 1996; Smucker et al., 2005). The effects of fire and burn severity may be intensified or mediated by time, and consequently, time since fire is one of the most important factors influencing wildlife composition and abundance in burned forests (Fisher and Wilkinson, 2005; Smucker et al., 2005; Haney et al., 2008). Within a relatively short period after fire, cover of herbs and shrubs increases, trees die, snags fall, and insect populations increase (Raphael et al., 1987; Ferrell, 1996; Bradley and Tueller, 2001; Bagne et al., 2008), altering resources available to wildlife. The response of a particular species or group may not be detectable in the first years after fire, or it may change or intensify over time (Fisher and Wilkinson, 2005; Smucker et al., 2005).

By determining the habitat factors that are most important for re-colonization of burned areas by wildlife, effective management may accelerate the establishment of wildlife. Several habitat features are likely to impact species diversity and abundance and may influence response following fire including shrub and herbaceous cover, downed wood (Raphael et al., 1987), and the number of snags suitable for nesting and denning (Bagne et al., 2008) . However, wildlife response may also be influenced by human alteration of natural landscapes, including urbanization and post-fire tree harvest (hereafter "PFH"). Urban development has been shown to reduce and degrade habitat and increase invasion by nonnative species in unburned areas (reviewed in McKinney, 2002), and these effects are likely to impact burned forests as well. This suggests that urbanization may have a negative impact on wildlife response to fire. PFH treatments are implemented to reduce risk of future fire and damage to human life and property through the removal of dead or dying trees from burned areas, and may also affect wildlife directly by altering habitat and indirectly by altering response to fire. The response of wildlife to fire may be negatively impacted by treatment, especially for species that are dependent on the high density of dead wood characteristic of burned forest (Hutto, 1995; Hutto, 2006; Saab et al., 2009).

Species may be limited in their ability to re-colonize a burned area based on availability of resources needed for breeding or foraging, and these resources are affected by burn severity, urbanization, post-fire treatment, and time since fire. Certain species or ecological groups may be more abundant than others based on differences in resource use (Smucker et al., 2005; Saab et al., 2007a). Songbirds and small mammals constitute the majority of vertebrate species in montane forests, and they serve an important function as the primary prey for the majority of upper trophic level species. In addition, birds and small mammals have been shown to be sensitive to alterations in forest structure and composition resulting from fire (e.g., Saab et al. 2007b, Converse et al. 2006). Ants are another important group that provide ecosystem services (Folgarait, 1998; Lobry de Bruyn, 1999) and are sensitive to alterations in habitat (Thompson and McLachlan, 2007; Sanford et al., 2008). Ants also serve as an important prey base for many species. By focusing monitoring efforts on these groups, we may determine how to best manage post-burn forests in the wildland-urban interface.

The Angora Fire burned approximately 3,100 acres in South Lake Tahoe, California in June and July 2007. The fire occurred in an area with high intermix of private and public land, adjacent to large expanses of undeveloped public land. The severity of the fire varied within the burned area, resulting in a mosaic of conditions. The primary post-fire actions have been to implement erosion control measures and to remove hazardous trees. The removal of snags and logs, even those that are highly scorched, is likely to reduce the ability of areas to support wildlife species dependent upon these features. The objective of this study is to determine the relative influence of burn severity and post-fire restoration activities on wildlife response in the first three years following the fire. This information can be used to guide management of this burned area and future burns if they occur. Management informed by monitoring will ensure that multiple resource objectives are being achieved.

Sampling Design

We addressed the following questions:

1. How do bird, small mammal, and ant communities vary with burn severity and time since fire?
2. What effect does PFH have on birds, small mammals, and ants?
3. How does urbanization impact bird, ant, and small mammal communities after wildfire?
4. What habitat characteristics are most important for the re-colonization of birds, small mammals, and ants in a post-fire landscape?

The primary public lands burned in the fire were United States Forest Service (USFS) and California Tahoe Conservancy (CTC) State lands. Following the Angora fire, managers from both the CTC and USFS determined that much of the burned area should be treated to reduce future risk of fire and loss of human life and property. In late 2007, some CTC urban parcels received PFH treatments. In 2008 and 2009, some USFS sites were treated to improve safety, primarily along the wildland-urban interface and around trails. Additional PFH treatments were planned for the majority of the fire footprint on USFS land; however, these were not completed at time of writing. Because much of the planned treatment had not been completed when data were collected, the sample size of treated sites was small and treatment was largely limited to hazard tree removal near houses and trails.

The USFS Pacific Southwest Research Station and Region 5 Ecology Program and the University of Montana established a systematic grid of points spaced 400m apart across the fire area to monitor post-fire vegetation response (Safford et al. 2009; Fig. 1). This grid map and additional monitoring points on CTC land were used to select sites based on burn severity and treatment. We attempted to obtain a balanced sample of sites that represented all combinations of burn severity (no burn, <20% mortality (low burn severity), 20-70% mortality (moderate burn severity), and >70% mortality (high burn severity), post-fire treatment (none or treated), and degree of urbanization (<20% impervious surfaces, >20% impervious surfaces) from the combined set of CTC monitoring plots, CTC parcels, and USFS monitoring grid points. Core sites were sampled for three years after fire to measure the short-term response of the forest and wildlife communities. New sites were added each following year and sampled for that year only to increase our sample size in the various treatment types and allowed us to survey a greater area of the burned forest. The distribution of sites among burn severity, PFH treatments, and degree of development is provided in Table 1.

Table 1. All sites sampled in 2008-2010 in the Angora fire area. Numbers in parentheses represent core sites that were sampled in all three years for birds and small mammals. Ant data is from 2008 only.

Sites sampled for birds	**Treated**		**Untreated**		**Total**
Burn severity	**Urban**	**Wild**	**Urban**	**Wild**	
High	4 (4)	6 (3)	6 (4)	26 (5)	42 (16)
Moderate	0	1	6 (4)	19 (7)	26 (11)
Low	5 (4)	0	2 (1)	8 (2)	15 (7)
None	0	0	6 (1)	9 (3)	15 (4)
					98 (38)
Sites sampled for small mammals	**Treated**		**Untreated**		**Total**
Burn severity	**Urban**	**Wild**	**Urban**	**Wild**	
High	3 (1)	5 (3)	2 (1)	20 (4)	30 (9)
Moderate	0	1	3 (1)	11 (4)	15 (5)
Low	3 (1)	0	2	6 (2)	11 (3)
None	0	0	6 (1)	7 (1)	13 (2)
					69 (19)
Sites sampled for ants	**Treated**		**Untreated**		**Total**
Burn severity	**Urban**	**Wild**	**Urban**	**Wild**	
High	4	4	2	7	17
Moderate	0	1	5	7	13
Low	3	0	1	2	6
None	0	0	1	3	4
					40

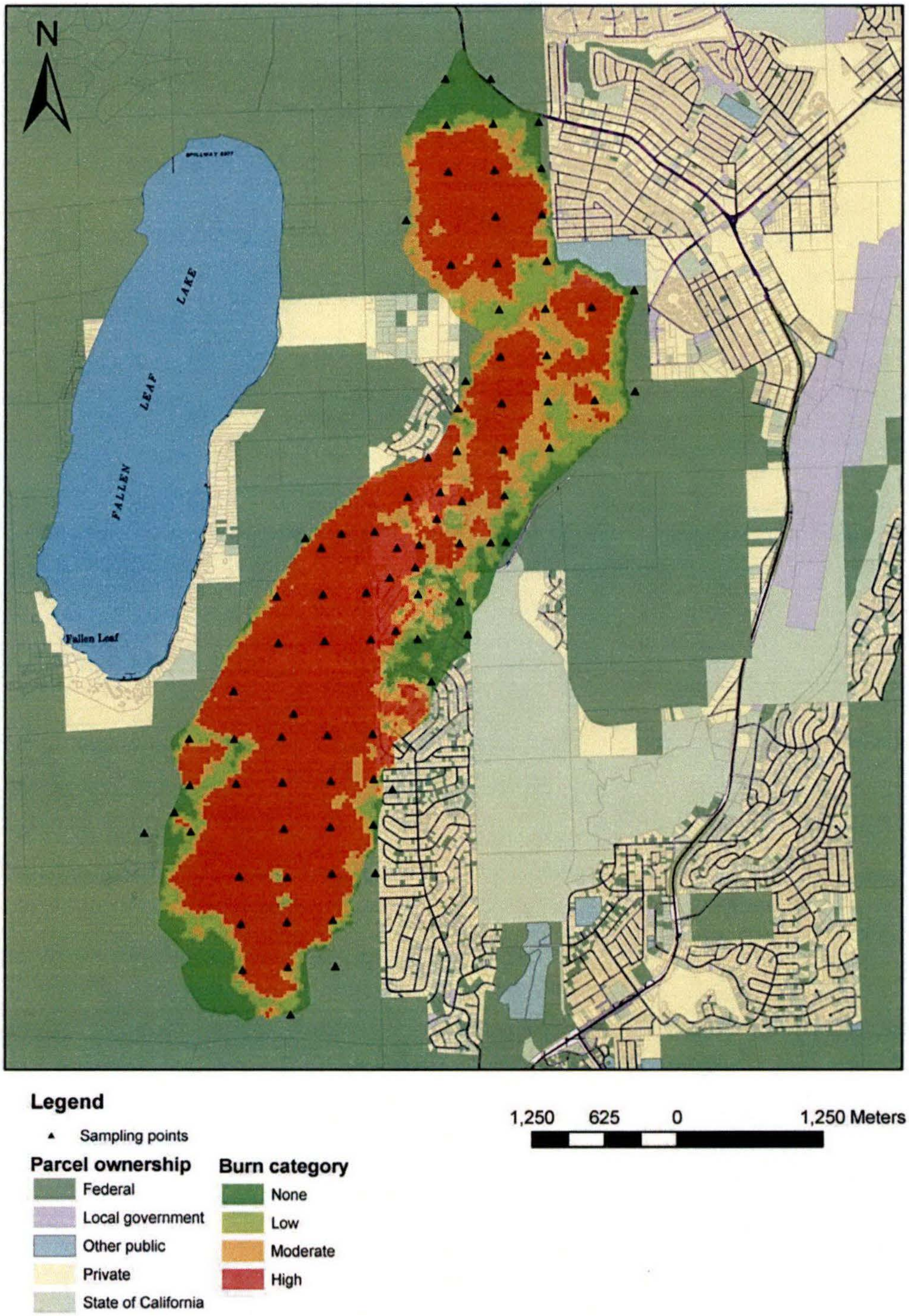

Figure 1. Angora fire footprint and sites

Methods

Habitat

A detailed description of vegetation sampling is provided in Appendix A and in Safford et al. (2009). Density of live trees (hereafter "trees") and snags and percent cover of shrubs and herbs were characterized in 1/5ac plots. All trees were identified to species, measured for diameter at breast height (DBH), and assigned to a diameter classes of small (11-24in), medium (24-36in), and large (>36in) categories by DBH. Densities for each class were calculated as stems per hectare. Coarse woody debris, ground cover, and plant species composition and cover were recorded in a total of twenty 0.5m quadrats evenly spaced along 64m of transects. Coarse woody debris was divided into small (< 12in) and large (> 12in) diameter classes and percent cover for each site was calculated using methods described in Waddell (2002). Additionally, burn severity, percent cover of vegetation classes (derived from the California Wildlife Habitat Relationship database), and percent cover of impervious surfaces (degree of urbanization) were extracted with a Geographic Information System (GIS) in ArcGIS 9.2 (ESRI, Redlands, CA) in 100m buffers around each point. This distance was selected because it represents the maximum area in which bird detections were recorded and roughly corresponds to the size of the small mammal trapping grid. Burn severity was based on tree mortality ratios (Salvador et al., 2000) obtained from USFS LANDSAT data. Analysis of Covariance (ANCOVA) was utilized to determine the effect of PFH treatment on habitat characteristics, with burn severity and degree of urbanization as covariates. This method allows for differentiation and interaction of effects of treatment, development, and burn severity on the density of trees and snags, percent cover of coarse woody debris, and percent cover of shrubs and herbs.

Wildlife

Bird surveys were conducted at 38 core sites in all years, with 26 additional sites in 2009 only and 31 additional sites in 2010 only. Due to changes in PFH treatment scheduling and logistics, one other site was sampled in 2008 and 2009 only, and two other sites were sampled in 2009 and 2010 only. Birds were surveyed at one point count station located at each site center. Counts were 10 minutes in duration, recording all individuals seen or heard within 100m. Three counts were conducted at each site in the month of June with a minimum of three days separating each count. Several observers conducted the counts, with at least two observers counting at each site to reduce observer bias. Species richness for each site and each year was defined as the maximum number of unique species detected across all visits within 100 meters of each point count station. Average abundance for each site was calculated over the three visits for each species detected within 100 meters of the point count station for each year.

Twenty core sites were sampled all three years for small mammals, with 10 additional sites sampled in 2008, 22 additional sites in 2009, and 19 additional sites in 2010. Small mammals were live trapped in a grid centered on sampling points. Sherman traps (H.B. Sherman Traps, Tallahassee, FL) were laid in a 5x11 grid (n = 55 traps) of extra-long (n = 40) and extra-large (n = 15) traps in an alternating pattern. Grids were rectangular to conform to the configuration of most parcels and PFH treatments. Traps were set and pre-baited (oats, seeds and peanut butter mix) for three nights prior to sampling, then opened and trapped for three nights in 2008 and five nights in 2009 and 2010. Traps were checked twice per day. Animals

were identified to species, weighed, assigned a sex and breeding status, and either ear-tagged or fur-clipped (voles and shrews, mice 2008-2009) for identification. Total abundance of mammals and abundance for each species was calculated based on catch-per-unit effort (Appendix B). Species richness and the total number of individuals captured over the trapping session were also calculated for each site.

Composition and relative abundance of ants were characterized with a grid of pitfall traps at 40 sites. We arranged 12 traps in a 40 x 40m grid, with four traps, spaced 10m apart, along each of three 40-m transects that were oriented north-south and centered on the center point of each plot; the three transects were separated by 20m (Bestelmeyer and Wiens, 1996; Anderson, 1997). Pitfall traps consisted of 6.5cm diameter (120ml) plastic cups with approximately 25ml of propylene glycol. Traps were left open for seven days and then the contents were collected. Ants were identified to species whenever possible, and abundance of each species and number of species were summed over all transects to obtain total abundance and species richness for each site.

To determine how burn severity affected wildlife, and whether the response varied with time since fire, PFH treatment, and degree of development, we conducted a multi-factor, repeated-measures Analysis of Variance (ANOVA) for birds and small mammals and multi-factor ANOVA for ants. We used bird, small mammal, and ant species richness, total abundance, and abundance of species detected at greater than 20% of sites as response variables (Appendix C). Species that are not well sampled with point counts, including raptors, shorebirds, and ducks were excluded from analysis. Burn severity was categorized as none (<1% tree mortality), low (1-20% tree mortality), moderate (20-70% tree mortality), and high (>70% tree mortality). For bird and small mammal analyses, fixed factors included burn severity, time since fire (2008= year 1, 2009= year 2, 2010= year 3), PFH treatment, and development and all 2-way interactions.. For ant analyses, factors included burn, PFH treatment, and development, and interaction effects of burn and development. A Tukey post-hoc test was used to determine significant differences between groups.

We modeled the abundance of ecological groups based on habitat variables in order to describe those with the greatest impact on wildlife response. Ecological groups were based on foraging and nesting strategies, and average abundance was calculated for each (Appendix C). Ecological groups provide an increased sample size over species-level analyses and better determine the habitat conditions required to maintain ecosystem function. Birds were assigned to ecological groups composed of ground insectivores, ground granivores, ground omnivores, foliage gleaners, aerial insectivores, and bark foragers. Mammals were assigned to one of six ecological groups: tree squirrels, ground squirrels, chipmunks, mice, voles, or shrews. Mammal groups were largely based on phylogeny, but also generally align with habitat and foraging preferences. Ants were assigned to one of four groups: aerators, compilers, decomposers, or generalists, based on nest structure and foraging technique (Sanford et al., 2008). Multiple linear regression was used to determine the environmental factors that most strongly influenced species richness, the total abundance of birds, small mammals, and ants, and the abundance of each ecological group. Akaike's Information Criterion (AIC) was calculated to select the most parsimonious models for each response variable and models within two AIC points of the top model were considered strongly supported (Burnham and Anderson, 2002). The importance of each explanatory variable for each response variable was also calculated as the sum of weights (w_i) for each model that included the parameter. The magnitude and direction of influence is

indicated by the β value for the parameter. Variables with 50% of the summed model weight are considered strong influences on the response. All of the habitat variables were entered into the regression analysis, but models were restricted to a subset based on the recommendation of ten sampling points per predictor variable. Models consisted of the seven most influential variables for birds and four most influential variables for small mammals and ants. Data were prepared by transforming explanatory variables and identifying and modifying outliers (Appendix D) to meet the assumptions of the linear model. All variables were standardized and data were analyzed with SAS 9.2 (SAS Institute, Inc. 2008, Cary, NC).

Results

Sites sampled ranged in elevation from 1,900 meters to just over 2,200 meters and were dominated by mixed coniferous forest, with patches of shrub and wet meadow/riparian habitats. Frequency of the most common forbs, graminoids, shrubs, and trees is summarized in Appendix C. Two plant species occurred at more than 50% of the study sites: Whitethorn Ceanothus (*Ceanothus cordulatus*), a shrub; and Spreading Groundsmoke (*Gayophytum diffusum*), a forb. The most common species of tree observed were Jeffrey Pine (*Pinus jeffreyi*, 32.9% of total stems observed) and White Fir (*Abies concolor*, 40% of total stems observed), found at 85.4% and 75.7% of sites, respectively.

Habitat

Results from ANCOVA indicate that burn severity, PFH, development, and time since fire greatly affected the structure and composition of the forest (Table 2, Fig. 2 and 3). Density of trees was negatively impacted by increasing burn severity and time since fire, with a stronger response in 2010 than earlier years, especially in low and highly burned sites. This may be attributed to the death of damaged trees over time. Density of trees was also impacted by development, with higher mean tree density in urban sites than wild sites. There were no interaction effects observed for burn severity, development, and year. Snag density was impacted by several environmental variables. Predictably, snags increased with increasing burn severity, and this relationship varied with PFH. PFH reduced the density of snags such that post-treatment snag density was uniformly low regardless of burn intensity. Development also impacted the density of snags, with lower snag densities in urban sites compared to wildland sites, presumably as a function of thinning to reduce the risk of fire near urban developments, which occurred prior to the fire.

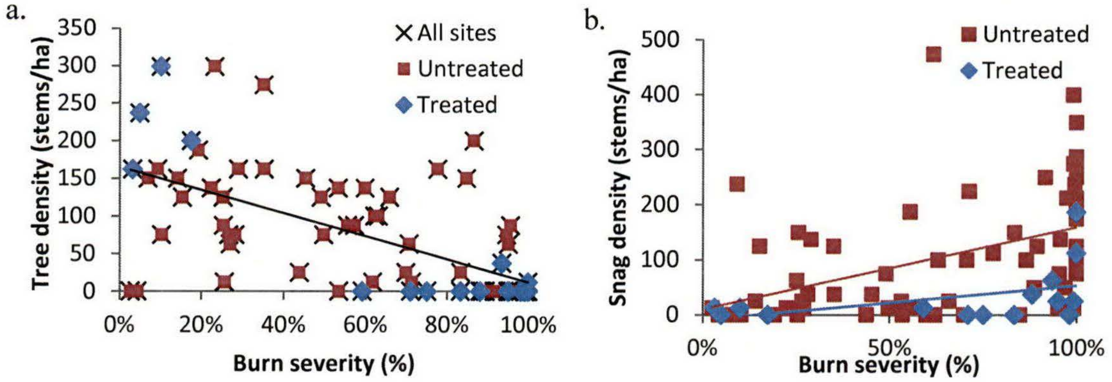

Figure 2. Density of trees and snags by treatment and burn severity: a. Tree density. b. Snag density

Ground cover was also affected by the environmental variables (Table 2, Fig. 3). Coarse woody debris (CWD) was not significantly influenced by burn severity or time since fire, suggesting that the amount of debris created is roughly equivalent to the amount destroyed within the first years after fire. In fact, only wildland and urban sites differed in percent cover of CWD, with higher mean cover in wildland sites. Herbaceous cover was also not significantly impacted by burn severity. Percent cover of herbs did differ by development; with higher mean cover in urban sites. Herbaceous cover also varied by year, with significantly higher mean cover in the third year after fire than the first. Herbaceous cover was not significantly impacted by any interaction effect. Percent cover of shrubs was positively influenced by burn severity. While we did not find significant post-hoc results to determine how each year differed, mean shrub cover differed significantly by year, generally increasing from the first year after fire. When we examined how time affected the response to burn severity, we found that shrub cover was significantly higher in the third year after fire, with greatest increases observed in highly burned sites. PFH treatment had a negative effect on shrub cover, with lower mean percent cover in treated sites than untreated sites. Shrub cover was also influenced by the interaction of burn severity and development. In urban sites, shrub cover was not influenced by burn severity, however, in wildland sites, shrub cover increased with increasing burn severity, suggesting shrubs recovered faster in wildland sites.

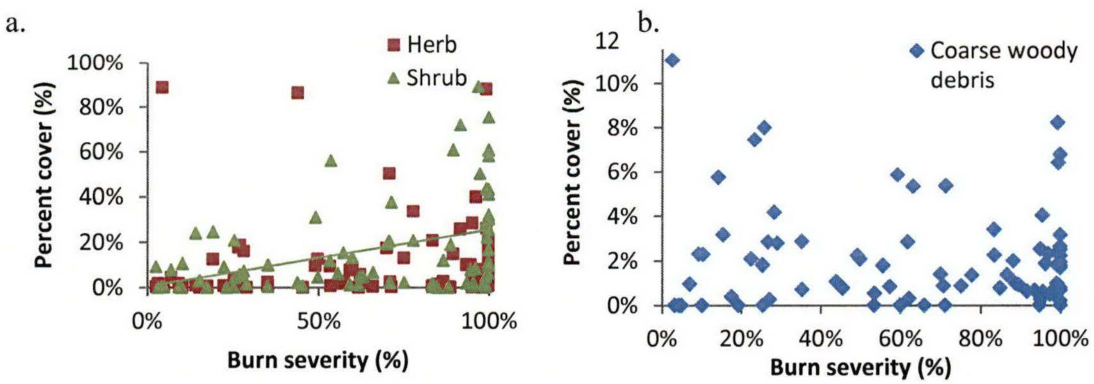

Figure 3. Ground cover response to burn severity: a. Shrub cover b. Percent cover of coarse woody debris

Table 2. Response of forest conditions to burn severity, PFH treatment, development, and time since fire. **Bold** values are significant at α<0.05.

Factor	Tree density	Snag Density	CWD	Herb cover	Shrub cover
Burn severity	**$F_{1,79}$=55.42, p<0.01**	**$F_{1,79}$=14.38, p<0.01**	$F_{1,79}$=2.32, p=0.13	$F_{1,79}$=0.54, p=0.46	**$F_{1,79}$=20.9, p<0.01**
Time Since Fire	**$F_{2,79}$=6.37, p<0.01**	$F_{2,79}$=2.87, p=0.06	$F_{2,79}$=1.58, p=0.21	**$F_{2,79}$=3.29, p=0.04**	**$F_{2,79}$=13.47, p<0.01**
Treatment	$F_{1,79}$=2.41, p=0.12	**$F_{1,79}$=4.50, p=0.04**	$F_{1,79}$=1.17, p=0.28	$F_{1,79}$=0.93, p=0.34	**$F_{1,79}$=6.52, p=0.01**
Development	**$F_{1,79}$=7.77, p<0.01**	**$F_{1,79}$=6.50, p=0.01**	**$F_{1,79}$=7.23, p=0.01**	**$F_{1,79}$=10.41, p<0.01**	$F_{1,79}$=2.02, p=0.16
Burn * Year	**$F_{2,79}$=3.27, p=0.04**	$F_{2,79}$=0.54, p=0.58	$F_{2,79}$=1.70, p=0.19	$F_{2,79}$=0.56, p=0.57	**$F_{2,79}$=3.80, p=0.03**
Burn * Treatment	**$F_{1,79}$=6.09, p=0.02**	$F_{1,79}$=3.83, p=0.05	$F_{1,79}$=0.16, p=0.69	$F_{1,79}$=1.21, p=0.28	**$F_{1,79}$=3.95, p=0.01**
Burn * Development	$F_{1,79}$=0.10, p=0.76	$F_{1,79}$=0.14, p=0.70	$F_{1,79}$=2.27, p=0.14	$F_{1,79}$=0.57, p=0.45	**$F_{1,79}$=6.75, p=0.01**

Wildlife

Avian response to burn severity, time since fire, urbanization, and treatment

In 2008, 66 bird species were detected across the 40 core sites sampled. Four species were observed on greater than 80% of all sites: Steller's Jay, Mountain Chickadee, American Robin, and Dark-eyed Junco. In 2009, 80 bird species were detected across all 66 sites sampled, with 73 species detected in the core sites. All the same species as 2008, with the addition of Western Wood-peewee and Brown-headed Cowbirds, were observed at greater than 80% of sites. In 2010, 72 bird species were detected across the 72 sites sampled, with 69 species detected at the core sites. In 2010, the previous species were detected, with the addition of Hairy Woodpecker, at greater than 80% of sites. A full list of species with frequency of detection is provided in Appendix C. A total of 98 sites were included in multi-factor, repeated measures ANOVA analysis to determine the effects of year, burn, urbanization and PFH treatment on total abundance, species richness and the abundance of 36 species of birds. Results from the ANOVA indicate that burn severity and time since fire played important roles in the composition of the bird community after fire (Table 3, Fig. 4, 5, 6).

Differences were observed in the mean abundance of several species of birds across the burn severity categories (Fig. 4 and 5). The Evening Grosbeak was the only species that appeared to be negatively impacted by fire, with higher abundance in unburned sites than sites

with low, moderate or high burn severity. The Mountain Chickadee, Red-breasted Nuthatch, and Yellow-rumped Warbler responded neutrally to low and moderate severity burns, but had significantly lower abundances in high severity burn areas. The abundance of many species was significantly higher at sites with some level of burn severity compared to unburned sites. The American Robin, Pine Siskin, and Steller's Jay were found in higher abundance in low burn severity sites than moderate or high burned sites. The mean abundance of Black-headed Grosbeak was greater in low burned sites than in both unburned sites and highly burned sites. Abundance of Western Bluebird, Mountain Bluebird, and House Wren were all significantly greater in highly burned sites than in unburned, low, or moderately burned sites. Black-backed Woodpecker abundance was greater in highly burned sites than in sites of low or no burn and Olive-sided Flycatcher abundance was greater in highly burned sites than unburned sites. Abundance of Hairy Woodpecker was greater in high severity sites than moderate or low severity sites. Abundance of Lazuli Bunting was also greater in high severity burns than in moderately and low burned sites, although the results of the post-hoc test were only marginally significant. Species richness of birds was higher in sites with high burn severity than low burn severity. The mean total abundance of birds and the mean abundance of 18 species of bird did not differ significantly across all categories of burn severity, indicating a neutral response.

Time since fire played an important role in community composition (Fig. 6). Only one species had significantly higher average abundance in the first year after fire than the third year: the Western Tanager. Tanagers were also more abundant in the second year post-burn than the third year. Total abundance of birds and the abundance of eight species of bird increased from the first year after fire, including Brown Creeper, Cassin's Finch, Chipping Sparrow, House Wren, Lesser Goldfinch, Steller's Jay, White-crowned Sparrow, and Yellow-rumped Warbler. Of these species, abundance of Brown Creepers and Yellow-rumped Warblers was significantly lower in the first year after fire than in either subsequent year. For Cassin's Finch and House Wren, the increase in abundance was only significant between the first year post-fire and the third year. For Chipping Sparrow and Lesser Goldfinch, abundance was significantly greater in the second year after fire than the first, but there was no significant difference in abundance in the second year than the third. Abundance of Steller's Jay and White-crowned Sparrow was higher in the third year after fire than the second year only. Interestingly, species richness of birds and abundance of one species, the Lazuli Bunting, was highest in 2009, the second year after fire than in either the first or third years.

PFH treatment and development affected abundance in several bird species. Effects of PFH treatment were only significant for three bird species: Brown-headed Cowbird, Common Raven, and White-crowned Sparrow. All had higher abundance in treated sites versus untreated sites. Development impacted eight bird species. Species with higher mean abundance in urban versus wildland habitat included Brewer's Blackbird, Brown-headed Cowbird, and Steller's Jay. Olive-sided Flycatcher, Dusky Flycatcher, Townsend's Solitaire, Cassin's Finch, and Pine Siskin had higher mean abundance in wildland versus in urban habitat.

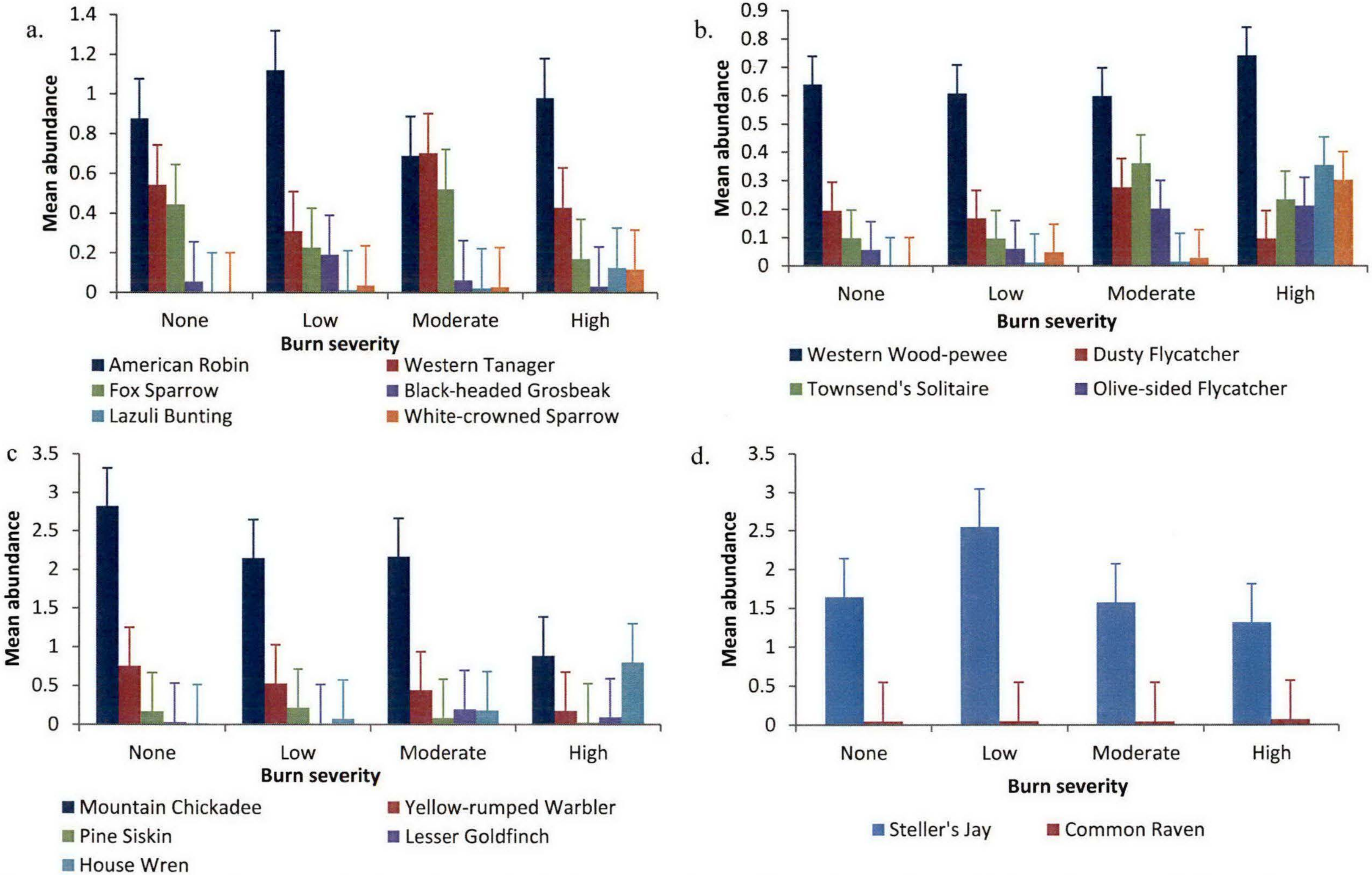

Figure 4. Response to burn severity by avian ecological group: a. Ground insectivores, b. Aerial insectivores, c. Foliage gleaners, and d. Omnivores

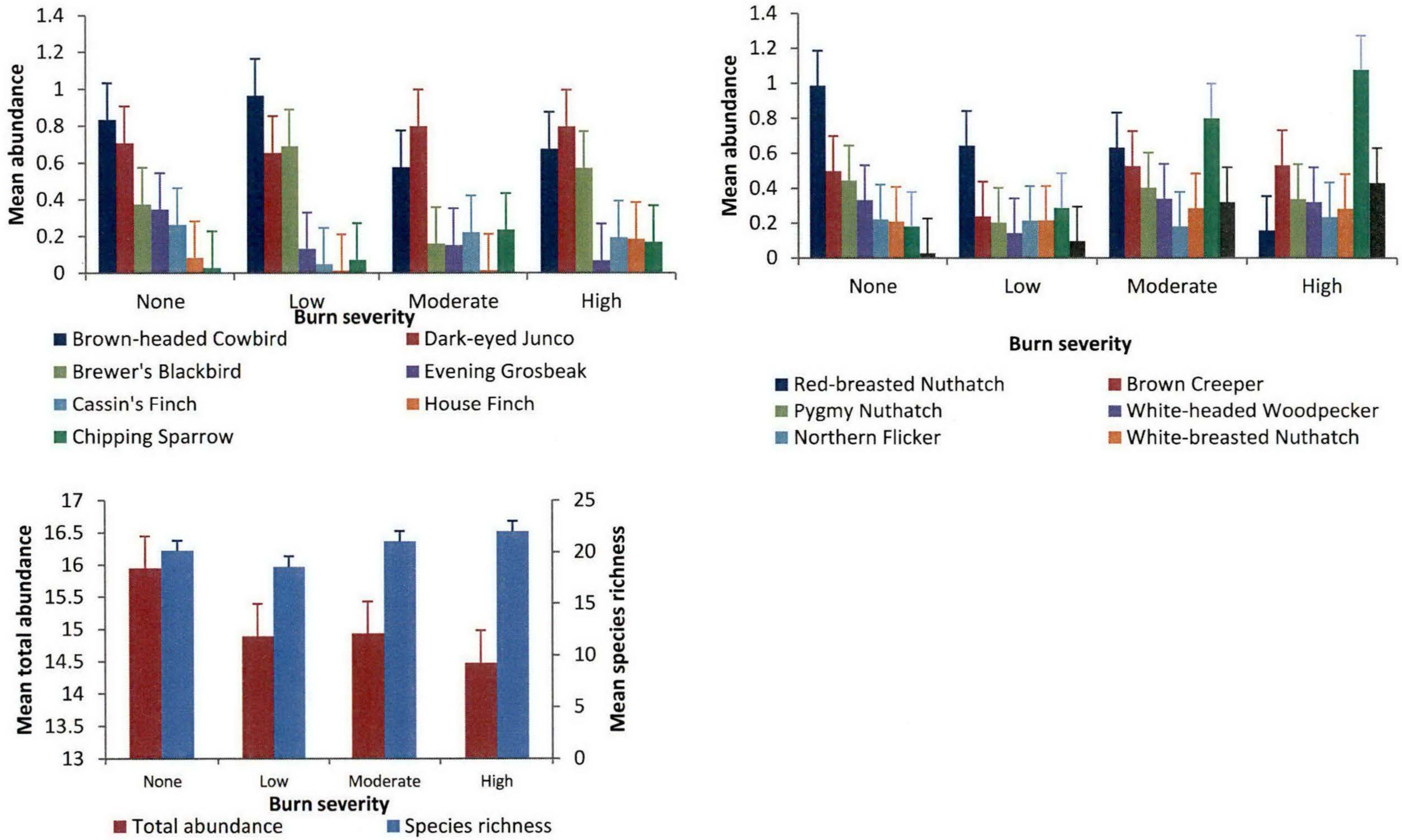

Figure 5. Response to burn severity by avian ecological group: a. Ground granivores b. Bark foragers and c. Total abundance and species richness of birds

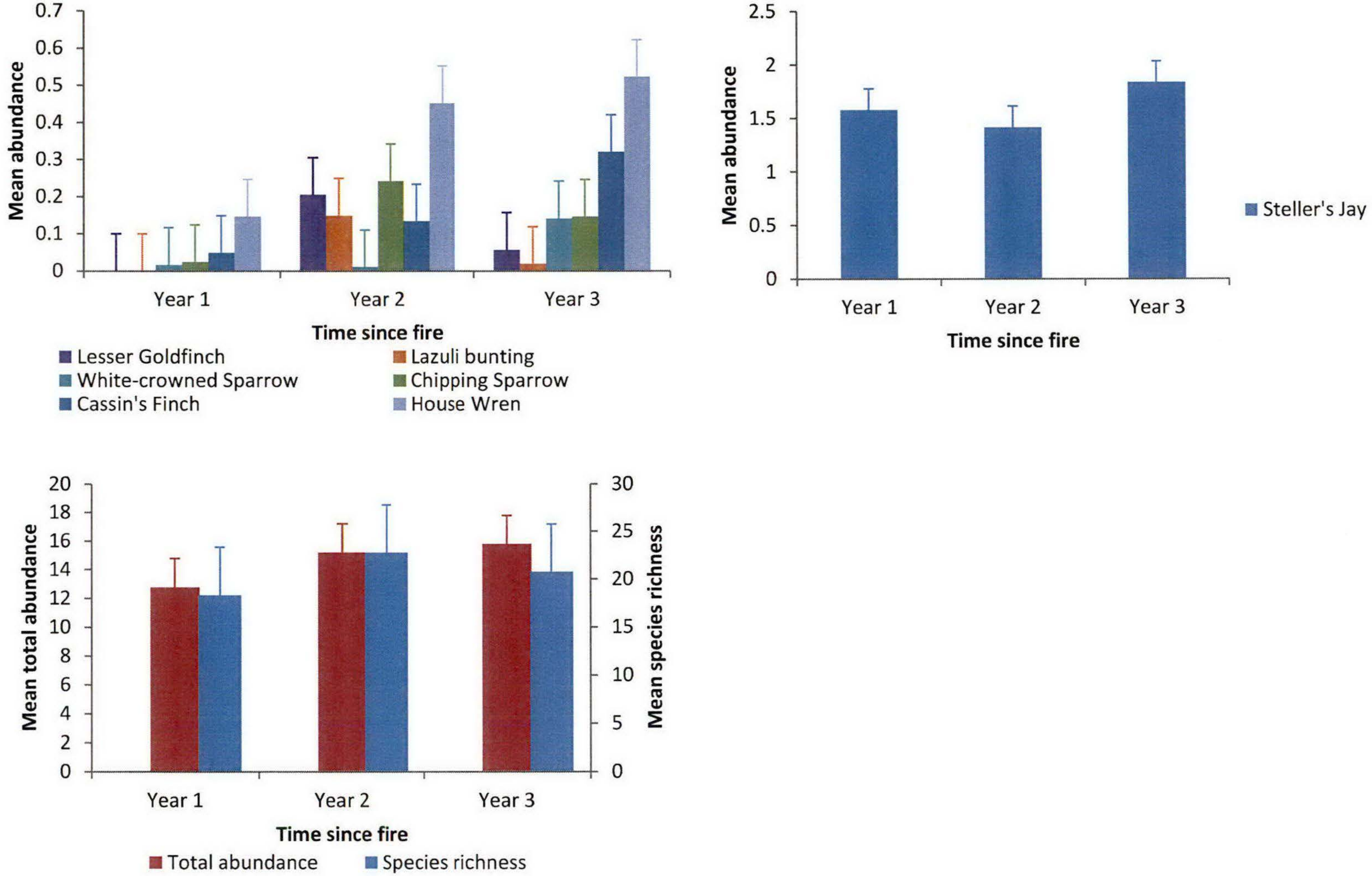

Figure 6. Effects of time since fire on avian response variables: a./b. species with significant year effect and c. total abundance and species richness of birds

Table 3. Response of bird community to year, development, PFH treatment, and burn severity. **Bold** values are significant at α<0.05.

	Year (df=2, 71)		**Development (df=1, 89)**		**Treatment (df=1, 89)**		**Burn (df=3, 89)**		**Burn * Year (df=6, 71)**		**Burn * Develop (df=3, 89)**	
Species	$F_{2,71}$	p	$F_{1,89}$	p	$F_{1,89}$	p	$F_{1,89}$	p	$F_{6,71}$	p	$F_{3.89}$	p
American Robin	0.49	0.61	3.02	0.09	0.38	0.54	2.75	0.05	1.62	0.16	0.26	0.85
Black-backed Woodpecker	0.24	0.79	2.17	0.14	1.51	0.22	**5.90**	**<0.01**	0.51	0.80	0.15	0.93
Black-headed Grosbeak	1.67	0.20	3.67	0.06	0.83	0.36	**3.78**	**0.01**	1.75	0.12	**4.58**	**0.01**
Brewer's Blackbird	0.20	0.82	**5.30**	**0.02**	0.01	0.93	0.58	0.63	0.48	0.82	1.15	0.33
Brown Creeper	**9.85**	**<0.01**	0.34	0.56	0.93	0.34	1.37	0.26	0.43	0.86	2.50	0.06
Brown-headed cowbird	1.28	0.28	**25.07**	**<0.01**	**4.61**	**0.03**	1.10	0.35	1.38	0.24	1.16	0.33
Cassin's Finch	**5.32**	**0.01**	**4.41**	**0.04**	0.00	0.98	0.92	0.44	0.37	0.90	1.33	0.27
Chipping Sparrow	**3.89**	**0.03**	0.04	0.84	0.17	0.68	2.06	0.11	1.18	0.33	0.24	0.87
Common Raven	1.31	0.28	0.25	0.62	**7.41**	**0.01**	0.14	0.93	0.28	0.94	2.62	0.06
Dark-eyed Junco	1.25	0.29	0.07	0.80	0.43	0.51	0.62	0.60	0.42	0.86	0.17	0.92
Dusky Flycatcher	2.69	0.07	**6.16**	**0.01**	0.36	0.55	0.90	0.44	0.70	0.65	0.96	0.42
Evening Grosbeak	1.66	0.20	0.18	0.67	0.22	0.64	**5.27**	**<0.01**	2.14	0.06	**3.77**	**0.01**
Fox Sparrow	2.05	0.14	1.41	0.24	0.22	0.64	1.59	0.20	0.98	0.44	1.99	0.12
Hairy Woodpecker	1.91	0.15	2.97	0.09	1.94	0.17	**18.01**	**<0.01**	0.72	0.64	**4.53**	**0.01**
House Finch	1.23	0.30	2.06	0.16	0.11	0.74	1.77	0.16	1.03	0.41	0.83	0.48
House Wren	**3.15**	**0.05**	1.51	0.22	2.82	0.10	**7.60**	**<0.01**	1.95	0.09	**3.59**	**0.02**
Lazuli Bunting	**5.05**	**0.01**	1.06	0.31	0.29	0.59	**3.21**	**0.03**	**5.43**	**<0.01**	0.13	0.94
Lesser Goldfinch	**3.53**	**0.03**	0.17	0.68	1.68	0.20	2.38	0.07	1.26	0.29	0.25	0.86
Mountain Bluebird	0.50	0.61	2.24	0.14	0.01	0.94	**6.25**	**<0.01**	0.82	0.56	**3.02**	**0.03**

Species	Year (df=2, 71) $F_{2,71}$	p	Development (df=1, 89) $F_{1,89}$	p	Treatment (df=1, 89) $F_{1,89}$	p	Burn (df=3, 89) $F_{1,89}$	p	Burn * Year (df=6, 71) $F_{6,71}$	p	Burn * Develop (df=3, 89) $F_{3,89}$	p
Mountain Chickadee	1.44	0.24	0.62	0.43	1.93	0.17	**20.29**	**<0.01**	1.17	0.33	0.75	0.53
Mountain Quail	2.30	0.11	**3.80**	**0.05**	0.32	0.57	0.21	0.89	0.58	0.75	1.46	0.23
Northern Flicker	2.55	0.08	0.22	0.64	1.66	0.20	0.32	0.81	1.26	0.29	0.15	0.93
Olive-sided Flycatcher	0.19	0.83	**3.88**	**0.05**	0.00	0.98	**3.79**	**0.01**	0.85	0.53	0.17	0.92
Pine Siskin	2.37	0.10	**9.86**	**<0.01**	0.00	0.99	**8.02**	**<0.01**	0.76	0.60	**4.39**	**0.01**
Pygmy Nuthatch	0.34	0.71	0.00	0.95	1.29	0.26	1.03	0.38	0.90	0.50	0.32	0.81
Red-breasted Nuthatch	2.62	0.08	0.51	0.48	0.65	0.42	**10.11**	**<0.01**	0.80	0.57	0.98	0.41
Steller's Jay	**3.70**	**0.03**	**5.92**	**0.02**	0.13	0.72	**5.53**	**<0.01**	1.81	0.11	0.30	0.82
Townsend's Solitaire	2.95	0.06	**6.35**	**0.01**	2.18	0.14	2.44	0.07	1.48	0.20	0.25	0.86
Western Bluebird	1.20	0.31	0.02	0.89	0.63	0.43	**5.82**	**<0.01**	1.68	0.14	0.06	0.98
Western Tanager	**10.64**	**<0.01**	0.77	0.38	0.56	0.46	1.87	0.14	1.27	0.28	0.98	0.41
Western Wood-Pewee	0.29	0.75	0.03	0.86	0.00	0.97	0.51	0.68	0.86	0.53	1.61	0.19
White-breasted Nuthatch	2.60	0.08	0.01	0.92	0.17	0.68	0.37	0.77	0.81	0.57	1.01	0.39
White-crowned Sparrow	**4.45**	**0.02**	0.26	0.61	**12.18**	**<0.01**	1.59	0.20	**2.98**	**0.01**	**3.53**	**0.02**
White-headed Woodpecker	2.58	0.08	0.61	0.44	0.15	0.70	1.52	0.22	1.04	0.41	1.88	0.14
Yellow-rumped Warbler	**14.20**	**<0.01**	1.63	0.21	0.00	0.96	**6.52**	**<0.01**	1.42	0.22	**5.47**	**<0.01**
Total abundance	**6.68**	**<0.01**	0.12	0.73	0.03	0.87	0.63	0.60	2.15	0.06	1.53	0.21
Species richness	**16.27**	**<0.01**	0.01	0.92	0.09	0.77	**3.67**	**0.02**	1.92	0.09	1.67	0.18

Development also affected the response of several bird species to burn severity. Abundance of Mountain Bluebird was higher in wildland, high severity burned sites than in any other combination of development and burn severity. Abundance of Hairy Woodpecker was higher in high severity, wildland sites than in high severity, urban sites and moderate severity, wildland sites. House Wren abundance was higher in high severity, wildland sites compared to unburned and low burned wildland sites and urban sites of any burn severity. White-crowned Sparrow abundance was higher in urban, high severity sites than in urban, low severity sites. Abundance of Pine Siskin was higher in low burned sites in wildland areas than in high and moderate burns of either degree of development and low burned sites in urban areas. Yellow-rumped Warbler was more abundant in unburned wildland sites than in high, moderate and unburned urban sites and in high or moderate wildland sites. Abundance of Black-headed Grosbeaks was higher in unburned wildland sites than in wildland sites that burned at high or moderate severity and urban sites of unburned, moderate, and high severity sites. Evening Grosbeak had higher abundance in unburned sites in the wildland compared to moderate severity, urban sites and low severity sites of either degree of development.

Small mammal response to burn severity, time since fire, urbanization, and treatment

In 2008, 11 species of small mammals were captured. The most common species were Deer Mouse and California Ground Squirrel, detected at greater than 80% of sites. Fifteen species of small mammal were captured in 2009, with Deer Mouse, California Ground Squirrel, Long-eared Chipmunk, and Yellow Pine Chipmunk detected at greater than 80% of sites. In 2010, 14 species of small mammals were captured, and the same four species observed in 2009 were again detected at greater than 80% of sites. A full list of species with frequency of detection is provided in Appendix C.

Data from 69 sites were included in analysis to determine impacts of year, burn, urbanization, and PFH treatment on abundance of eleven species of small mammal, species richness, and total abundance of small mammals. Results from the ANOVA indicate that burn severity and time since fire also played important roles in the composition of the small mammal community (Table 4, Fig. 7, 8, 9). With the exception of the Douglas Squirrel, small mammals were found in higher abundance in low to moderately burned sites. Higher species richness of small mammals and abundance of Golden-mantled Ground Squirrel were observed at sites that burned at low severity than sites that burned at high severity. One species, the Long-eared Chipmunk, had significantly higher abundance in sites of moderate burn severity than both unburned and highly burned sites. The only small mammal that appeared to prefer sites that burned at high severity was the Deer Mouse, with higher abundance in high severity sites than moderate or low severity sites. Douglas Squirrels were found with higher abundance in unburned sites than sites that burned at any severity. The total abundance and abundance of six species of small mammal were not significantly different across all categories of burn severity, indicating a neutral response.

Total abundance and abundance of three species of small mammals increased from the first year after fire (Fig. 8): Lodgepole Chipmunk, Long-eared Chipmunk, and Long-tailed Vole. However, species richness and abundance of three species, Deer Mouse, Allen's Chipmunk, and Yellow-pine Chipmunk, were highest in 2009, the second year after fire. Development and the interaction of development and burn severity did not affect any small mammal species. Effects of

PFH treatment were only significant for one species, Montane Vole, which had higher mean abundance in treated sites than untreated sites. Two individual small mammal species and overall species richness (Fig. 9) differed with time and burn severity. Golden-mantled Ground Squirrels had higher mean abundance in low severity sites in year three compared to high severity sites in any year, moderate severity sites in years one and two, and unburned sites in year three. Abundance of Douglas Squirrels was also impacted by the interaction of time and burn severity, with higher abundance on low severity sites in year three compared to high severity sites in any year and low severity sites in year one and two. The impact of burn severity on species richness was especially evident in the year one, with lower richness in high severity burn sites than in both moderate and low severity burn sites in any other year. Species richness of small mammals was also higher in moderate severity sites in year two and three and in unburned sites in year two than in high severity sites in year one.

Table 4. Response of small mammal community to burn severity, PFH treatment, development, and year. **Bold** values are significant at $\alpha<0.05$.

	Burn (df=3, 60)		**Treatment (df=1, 60)**		**Development (df=1, 60)**		**Year (df=2, 31)**		**Burn * Year (df=6, 31)**		**Burn *Develop (df=3, 60)**	
	F	*p*	**F**	*p*	**F**	*p*	**F**	*p*	**F**	*p*	**F**	*p*
Douglas Squirrel	**3.30**	**0.03**	0.06	0.81	1.18	0.28	**7.12**	**<0.01**	**5.14**	**<0.01**	0.71	0.55
Northern Flying Squirrel	2.12	0.11	0.02	0.89	1.41	0.24	0.72	0.50	0.59	0.73	0.46	0.71
California Ground Squirrel	0.41	0.75	0.05	0.83	0.40	0.53	0.55	0.58	1.89	0.11	0.86	0.47
Golden-mantled Ground Squirrel	**4.02**	**0.01**	2.43	0.12	0.47	0.50	0.23	0.80	**3.56**	**0.01**	1.06	0.37
Allen's Chipmunk	0.08	0.97	1.87	0.18	0.08	0.78	**8.88**	**<0.01**	1.47	0.22	1.07	0.37
Lodgepole Chipmunk	**3.17**	**0.03**	2.10	0.15	1.76	0.19	**5.93**	**0.01**	1.38	0.25	1.61	0.20
Long-eared Chipmunk	**2.85**	**0.04**	0.44	0.51	0.12	0.73	**7.51**	**<0.01**	1.63	0.17	0.08	0.97
Yellow-pine Chipmunk	**2.84**	**0.05**	0.00	0.99	0.88	0.35	**8.54**	**<0.01**	0.93	0.49	1.77	0.16
Deer Mouse	**15.63**	**<0.01**	0.89	0.35	1.18	0.28	**44.62**	**<0.01**	1.89	0.11	0.21	0.89
Long-tailed Vole	1.25	0.30	0.27	0.60	1.41	0.24	**3.67**	**0.04**	0.72	0.64	1.47	0.23
Montane Vole	0.10	0.96	3.77	0.06	0.65	0.42	0.87	0.43	0.58	0.74	0.05	0.98
Total Abundance	0.36	0.78	0.71	0.40	0.07	0.79	**28.74**	**<0.01**	1.80	0.13	1.45	0.24
Species Richness	**3.32**	**0.03**	0.91	0.34	0.38	0.54	**8.90**	**<0.01**	**4.83**	**<0.01**	1.20	0.32

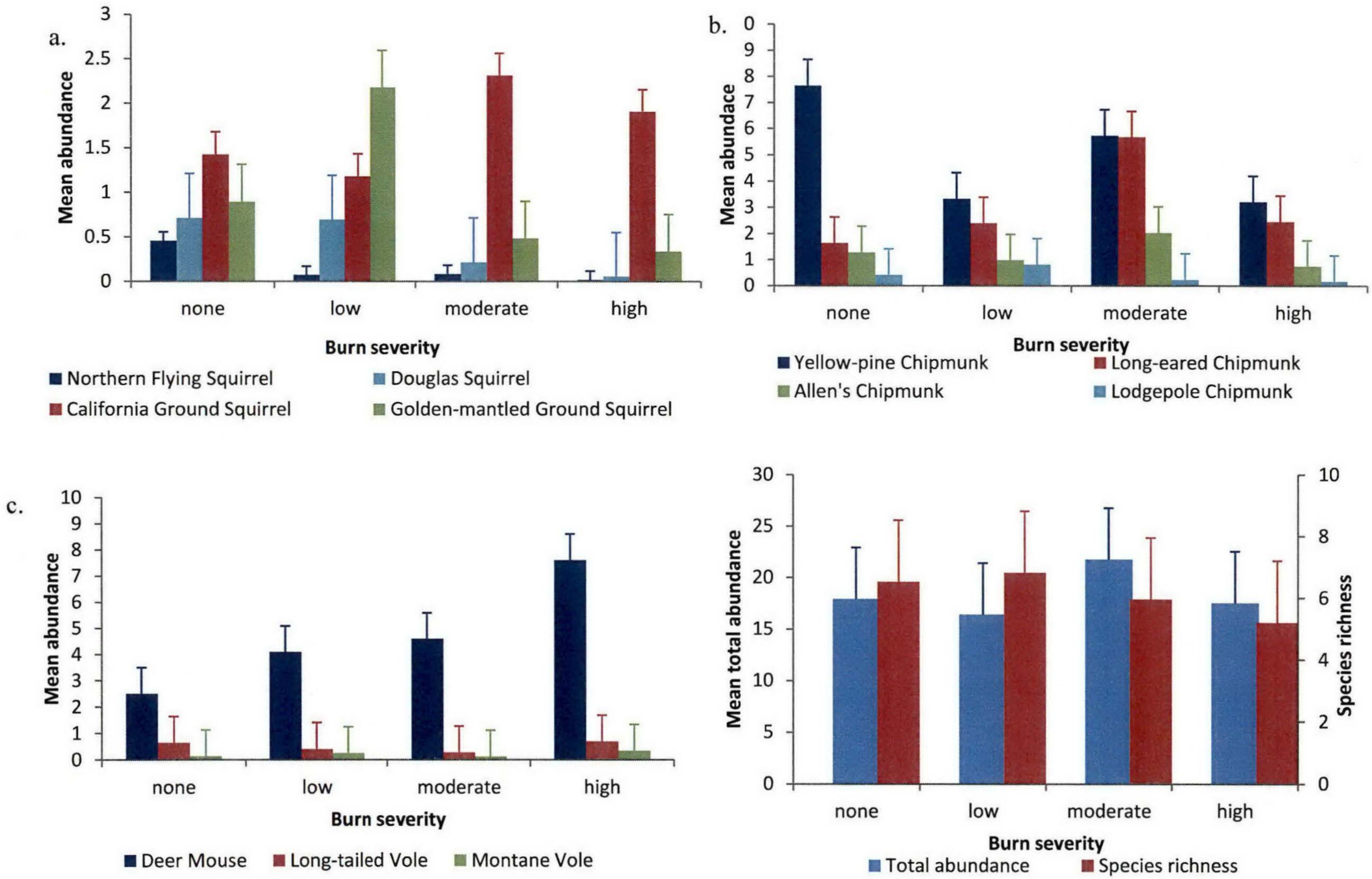

Figure 7. Response of small mammal community to burn severity: a. squirrels, b. chipmunks, and c. mice and voles.

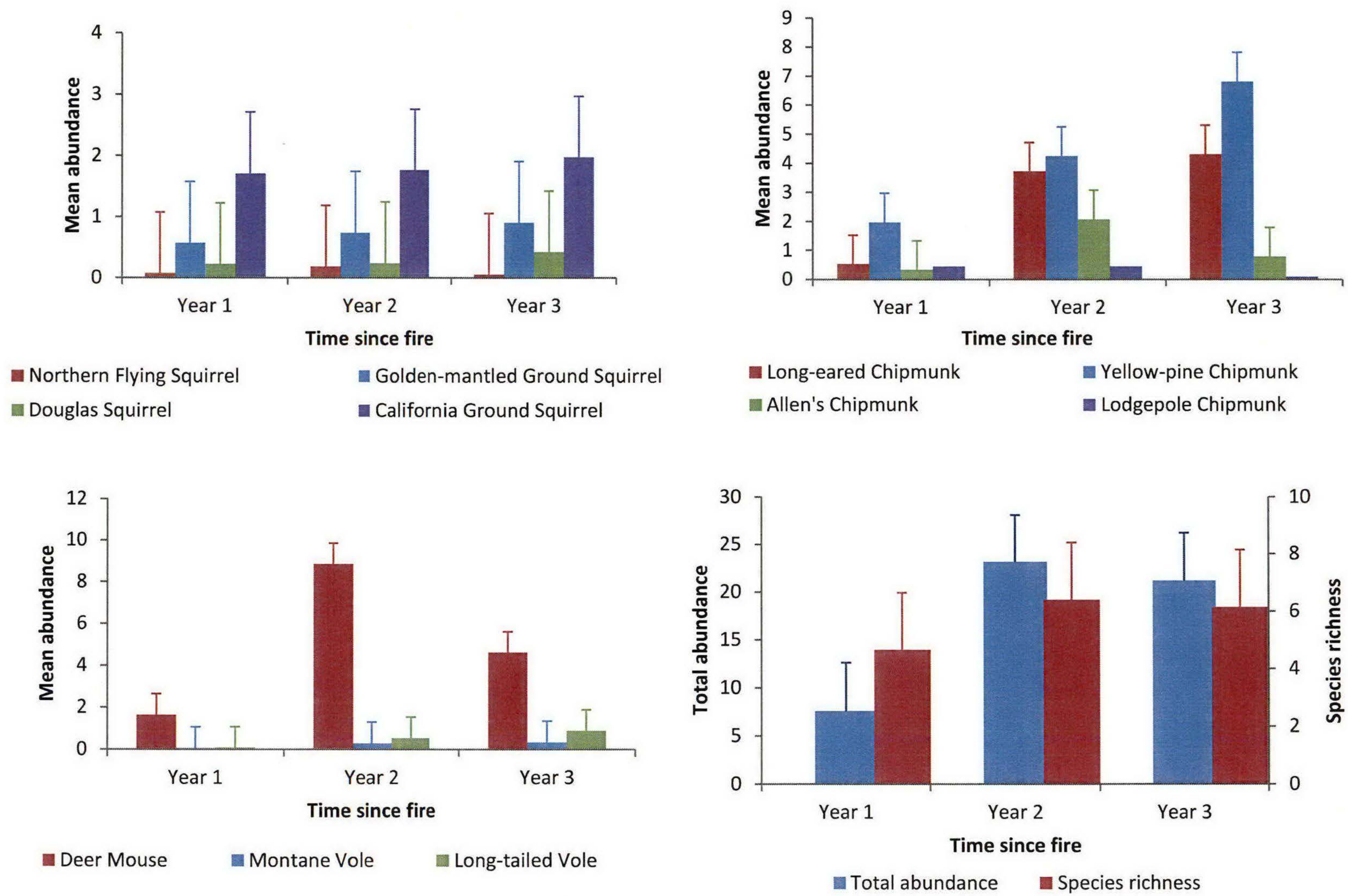

Figure 8. Small mammal response to time since fire: a. squirrels, b. chipmunks, and c. mice and voles.

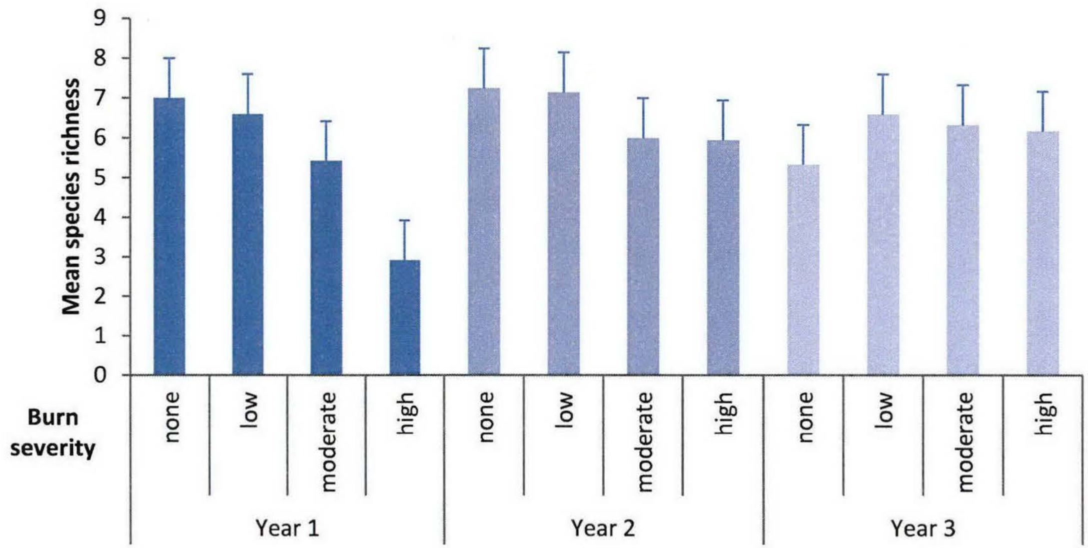

Figure 9. Species richness of small mammals with burn severity and time since fire

Ant response to burn severity, time since fire, urbanization, and treatment

Ant data were only available for 2008; we detected 11,647 ants representing 33 species in nine genera of ants across all 40 sites surveyed. Fourteen species of ants in six genera were observed at greater than 20% of sites. Three species of ants were detected at greater than 80% of sites: *Formica* cf *sibylla, F. fusca*, and *Camponotus vicinus*. A full list of species with frequency of detection is provided in Appendix C.

Data collected from 40 sites were included in analysis to determine impacts of burn, urbanization, and PFH treatment on abundance of 14 species of ants, species richness, and total abundance of ants. Results from the ANOVA indicate that burn severity and degree of development affected the species richness and the abundance of two species of ant, but most species responded neutrally to burn severity, PFH treatment, and development (Table 5). One species of ant, *Formica aserva*, had higher abundance in unburned sites than sites with low, moderate, or high burn severity. Species richness and total abundance of ants and abundance of 13 species of ant had no significant differences across all categories of burn severity, indicating a neutral response. Development affected one ant species, *Formica lasiodes,* and mean species richness which had higher mean values in urban sites. No PFH treatment effects were observed in any species of ant. There was no significant interaction effect between burn severity and development for any ant parameter.

Table 5. Response of abundance and richness of ants to development, PFH treatment, and burn severity. **Bold** values are significant at α<0.05.

	Development		**Treatment**		**Burn**		**Burn*Development**	
	df=1,31		**df=1,31**		**df=3,31**		**df=3,31**	
	F	*p*	F	*p*	F	*p*	F	*p*
Formica cf *sibylla*	0.00	0.96	0.02	0.90	0.61	0.61	0.24	0.87
Camponotus vicinus	0.15	0.70	0.31	0.58	1.53	0.23	0.34	0.80
Formica fusca	1.16	0.29	0.00	0.95	0.33	0.81	1.17	0.34
Formica microphthalma	0.28	0.60	0.70	0.41	0.84	0.48	0.42	0.74
Formica sibylla	0.44	0.51	0.70	0.41	1.33	0.28	2.58	0.07
Myrmica tahoensis	1.21	0.28	0.80	0.38	0.07	0.98	0.78	0.52
Formica lasioides	**7.09**	**0.01**	1.02	0.32	2.19	0.11	1.12	0.36
Aphaenogaster occidentalis	0.07	0.79	0.09	0.77	0.35	0.79	0.28	0.84
Formica aserva	1.28	0.27	0.10	0.76	**8.53**	**<0.01**	0.96	0.43
Camponotus modoc	1.14	0.29	0.00	0.95	1.54	0.22	1.08	0.37
Formica argentea	0.00	0.96	1.27	0.27	0.04	0.99	0.19	0.90
Lasius pallitarsis	0.00	1.00	0.35	0.56	1.15	0.35	0.03	0.99
Formica neorufibarbis	0.67	0.42	0.97	0.33	0.66	0.58	0.82	0.49
Tapinoma sessile	0.40	0.53	2.77	0.11	1.12	0.36	1.06	0.38
Total abundance	0.03	0.86	1.23	0.28	0.72	0.55	0.16	0.92
Species richness	**9.28**	**<0.01**	1.60	0.22	0.58	0.63	0.04	0.99

Factors influencing wildlife abundance and richness

We used linear regression to examine the most influential habitat components on ecological groups of birds, small mammals and ants. Best models from multiple linear regression analysis and variables with at least 50% of the summed model weight are given in Appendix E for birds, Appendix F for small mammals and Appendix G for ants. Data from all years were included in this analysis, with time since fire included as a covariate. Burn severity had very high importance across many models, and was positively associated with species richness of birds and abundance of aerial and bark foraging birds. Burn severity was negatively associated with species richness of small mammals and abundance of ground granivores and omnivores and foliage gleaners, chipmunks, and tree squirrels. Burn severity also was highly influential for ant community variables, with positive effects on species richness and total abundance and abundance of aerators and generalists. Abundance of compilers and decomposers was negatively impacted by burn severity.

Another important factor influencing abundance and species richness was time since fire. Time since fire positively influenced several bird variables including species richness, total abundance, and abundance of ground insectivores and foliage gleaners. It was also important in nearly all small mammal models, excluding abundance of tree squirrels and ground squirrels, and was positively associated with small mammal response variables. Time since fire had high importance for total abundance, species richness, and abundance of chipmunks, and voles.

Snag density was important for several wildlife response variables. Density of small and medium snags both positively influenced several bird parameters: species richness, total abundance, and abundance of bark foraging birds, foliage gleaners, and aerial insectivores. Density of medium snags also positively influenced abundance of ground omnivores. Density of both small and medium snags negatively influenced abundance of ground foraging birds. Large snags were positively associated with ground insectivores and granivores and bark foragers, but negatively associated with species richness and abundance of foliage gleaners. Snag density negatively influenced all small mammal parameters except abundance of mice. For ants, compilers and decomposers responded favorably to increasing snag density and species richness, whereas the total abundance and the abundance of aerators and generalists responded negatively.

Tree density was also important to re-colonizing wildlife communities. Density of small trees was positively associated with species richness and total abundance of birds and abundance of bark foragers, ground omnivores, and foliage gleaners and negatively associated with abundance of ground insectivores and granivores and aerial insectivores. Density of medium trees was positively associated with species richness, total abundance, and abundance of bark foragers, aerial insectivores, ground omnivores, and foliage gleaners and negatively associated with ground insectivores and granivores. Density of large trees was positively associated with species richness and aerial insectivores and negatively associated with abundance of all other bird parameters. Tree density did not account for at least 50% of summed importance for any small mammal response variable, but the response was positive for all groups, except the abundance of voles. Nearly all ant groups responded positively to increasing tree density, including aerators, compilers, and generalists. Species richness and total abundance of ants also increased with increasing tree density.

Several ecological groups responded strongly to some aspect of ground cover. For birds, species richness and total abundance and abundance of all foraging groups, except bark foragers, were positively associated with the percentage of herbaceous cover. Species richness and total abundance of small mammals, and the abundance of tree squirrels and voles also increased with increasing herbaceous cover. Herbaceous cover was not a strong predictor of abundance or species richness of ants. Shrub cover was more important for re-colonization of small mammals than for birds or ants. Shrub cover positively influenced species richness and total abundance of small mammals and abundance of chipmunks, ground squirrels, and tree squirrels. Percent cover of coarse woody debris (CWD) was also an important habitat component. Cover of small diameter CWD was a positive influence on the abundance of foliage gleaning birds, a negative influence on total abundance of birds and abundance of bark, aerial, and all groups of ground foragers. The total abundance and species richness of small mammals and the abundance of chipmunks, mice and voles were positively influenced by cover of small CWD. For small mammals, only the abundance of tree and ground squirrels were negatively impacted by increasing small CWD. All ant parameters, excluding abundance of compilers, were negatively influenced by small CWD. Large CWD had slightly different impacts, particularly for birds and small mammal groups. Several bird parameters, including species richness and the total abundance and the abundance of foliage gleaners, ground omnivores, and aerial insectivores were positively influenced by large CWD. The only negative relationship existed between large CWD and abundance of ground granivores. Species richness, total small mammal abundance and the abundance of mice and tree squirrels were also positively influenced by percent cover of large CWD. Abundance of chipmunks was negatively impacted by increasing large CWD cover, but positively influenced by small CWD cover. Percent cover of total CWD was negatively associated with species richness and total abundance of ants and all ant groups, with the exception of the compilers.

Although wetland habitat was limited within the study area, it was included in several models, indicating its importance to wildlife communities. Percent cover of wetland habitat was particularly influential to birds, positively associated with all parameters except abundance of ground omnivores. It was also positively associated with total abundance of small mammals and abundance of chipmunks. Percent cover of wetland habitat had a negative influence on small mammal species richness and the abundance of tree squirrels, ground squirrels, mice, and voles. Species richness and the total abundance of ants and the abundance of compilers were positively associated with wetland cover, while the abundance of aerators, decomposers, and generalists was negatively influenced by wetland cover.

Discussion

Fires in coniferous forests create a mosaic of habitats used by different species across multiple taxa. In the three years following the Angora Fire, we observed increasing shrub cover and density of snags and decreasing density of trees. Trees decreased over time as those that initially survived the fire succumbed to damage and died, resulting in higher snag densities. PFH treatment did not significantly affect tree density and most treatment efforts post-fire were focused on snags. Decreases in tree density create openings in the canopy, allowing for increasing shrub cover, particularly in highly burned sites. In the first year after fire, overall vegetation cover was low, although highly burned sites had somewhat greater percent cover than

low and moderately burned sites. This pattern continued in the second year after fire, with higher overall cover in highly burned sites, and slightly higher shrub cover than herb cover. Increases in ground cover may be attributed to decreased competition from trees for water and nutrients and increased access to sunlight due to lower canopy closure. Additionally, disturbed soils may encourage growth of highly dispersed annuals and other colonizing species. Shrubs common in the study area, such as *Ceanothus* and *Arctostaphylos* (Manzanita) species, often respond positively to fire. *Ceanothus cordulatus* (Whitethorn) and *Arctostaphylos patula* (Greenleaf Manzanita) resprout after moderate intensity burns, but they also regenerate from seeds, the former especially under hotter fire conditions. *Ceanothus prostratus* (Prostrate Ceanothus) is an obligate seeder (it does not resprout), and also germinates prolifically in response to hot fires. Most of the montane *Ceanothus* species are renowned for their ability to regenerate strongly from seed in forest stands that have experienced stand-replacing fires. In the third year after fire, shrub cover remained dominant in highly burned sites, but herbaceous cover dominated low burned sites. Herbaceous cover likely recovers more quickly in low to moderately burned sites because seeds remain viable in the seedbank in these areas, whereas seed viability is likely to be diminished in high severity burn sites and must be replaced by wind or animal-driven dispersal. Higher percent cover of shrubs and diversity of herbaceous cover may influence recruitment of aerial and ground insects, and therefore insectivorous birds and small mammals. Additionally, shrubs and herbs produce seeds and vegetation to support granivorous and herbivorous wildlife.

Habitat alterations associated with wildfire affected terrestrial wildlife in a complex manner. While some species decreased in abundance from unburned to burned habitat, most species increased in abundance at some level of burn severity. Species that did decrease (Evening Grosbeak, Douglas Squirrel, and *F. aserva*) were likely negatively impacted by damage to potential ground nesting sites and cone caches, or reductions in the availability of live trees for nesting sites and forage. Additionally, the Evening Grosbeak is highly nomadic and unpredictable in the study area, and may not actually be responding to fire, although it also depends on live trees. Three species had higher mean abundance in unburned, low, or moderate severity sites than high severity burn sites: Mountain Chickadee and Yellow-rumped Warbler, gleaners that also depend on live trees for forage, and the Red-breasted Nuthatch, a bark forager (Smucker et al., 2005). Low to moderate severity burns appear to offer sufficient nesting and foraging habitat to support these species, and potentially they are able to capitalize on the abundance of insects often occurring in post-burned forest (Martin et al., 2006, Parker et al., 2006). A wide range of other species were found in higher abundance in low and moderate severity burns compared to unburned or high severity burns, indicating that fire can have a positive impact on species with a wide range of life history characteristics (foraging, nesting, mobility).

Perhaps most interesting are the species that had higher abundance in high severity burn sites compared to other burn severity classes. This included several species considered burn specialists, such as Black-backed Woodpeckers and Mountain Bluebirds, as well as several species that appear to exploit the ephemeral increase in abundance of prey and nest habitat, such as Western Bluebirds, Olive-sided Flycatchers, and House Wrens. Highly burned sites also supported significantly higher avian species richness and Deer Mouse abundance than other burn severities. Also of note are the 37 species across all taxa that had no significant response to any burn severity, and did not vary in mean abundance, indicating that fire had a neutral impact on approximately one quarter of the taxa sampled.

By including time since fire in our analysis we were able to evaluate how wildlife abundance and species richness changed with time. Habitat conditions changed rapidly for tree density in the first years after fire and shrub cover increased in every year, but greatest increases were observed in the third year after fire. Conditions in burned forests change rapidly in the first years after fire, and these changes in habitat structure and resources impact the wildlife community (Brown and Smith, 2000). While many burned areas, especially severely burned areas, may appear devastated, they have value to bird, small mammal, and ant communities. In fact, most species with low abundance in the first year after fire were comparable to abundances in unburned areas by the third year. Species richness of small mammals, when burn response was examined over time, nearly returned to unburned values by year three in all burn severities. Interestingly, 2009, the second year after fire, had the highest species richness and total abundance of birds and small mammals, and highest abundance of several species. This pattern could be due to fluctuations in climate, with milder winter conditions over 2009 contributing to increased winter survivorship, earlier initiation of breeding, and increases in plant and insect food sources. A longer time-series of sampling would be needed to determine the trajectory of habitat suitability and community recovery post-fire.

Urbanization has been shown to impact wildlife communities by reducing native vegetation, inhibiting species movement, disturbing and modifying animal behavior, and increasing non-native predators, parasites, and competitors (reviewed in McKinney, 2002). The combined effects of urbanization and fire have largely been unstudied, although fire risk in the wildland-urban interface is higher than in wildlands. Four bird species were higher in abundance in wildland than urban forest sites and when we examined the effects of burn severity and development, we found that several other species were also negatively impacted. Our results suggest that burned urban forests do not provide the same habitat conditions as burned wildland forests, which is may be a function of pre-burn conditions associated with reduced habitat quality (vegetation composition and/or structure) and direct disturbance from human activities in urban areas. Re-colonization of burned forests in urban areas may be further hindered by species that generally responded positively or neutrally to fire. For instance, the mean abundance of nest parasites (Brown-headed Cowbird), nest predators (Steller's Jay), and other highly disturbance-tolerant species (Brewer's Blackbird) was higher in urban areas. This suggests that urbanization may indirectly impact long-term recovery through the increased pressure from nest parasitism, predation, or competition by urban-associated species (Trine et al., 1998; McKinney, 2002).

The effects of fire on wildlife are somewhat impacted by post-fire management, such as PFH, which may alter burned landscapes. PFH was negatively associated with snag density, reducing habitat quality for species that depend on snags for foraging, nesting, and denning sites. Although the effect on habitat was significant, few species in this study appeared to respond to PFH. This may indicate that PFH did not have an ecologically significant effect on wildlife in this study, which is likely a function of the small number and size of treated parcels. Additionally, the parcels that were treated were largely restricted to urban sites, as these were given high priority to reduce risk of further damage or injury to human property and life. Effects of treatment may have been masked by urbanization effects, which were largely negative, particularly for fire-specialist species, and positive for urban-adapted species. Because treatment was limited to urban sites, we could not discern the interaction of urbanization and treatment on wildlife species. Increasing sample size of treated and untreated sites, particularly with a before and after treatment sampling, will elucidate the relationship between treatment, habitat, and

wildlife response. This study provides a strong foundation of pre-treatment sites that could be resampled once planned tree harvest activities are completed in the area.

Burns create heterogeneous habitat, resulting in unique assemblages and high species diversity (Smucker et al., 2005; Saab et al., 2007a). PFH treatment may homogenize habitat and reduce foraging and nesting substrates and degrade the features that make burned habitat unique (Hutto, 1995). Not surprisingly, we found no significant difference in live tree density, percent cover of coarse woody debris, and understory vegetation between high severity burn sites that were treated and untreated. PFH targeted snags and indeed snag density was substantially lower in treated areas. This would explain why PFH did not affect species primarily dependent on these habitat features, such as tree squirrels, chipmunks, and many bird species. Species that responded favorably to PFH included species that prefer open, meadow-like habitat, such as the White-crowned Sparrow and Montane Vole, or species that are disturbance-tolerant, like the Common Raven and Brown-headed Cowbird.

We investigated the response of species and ecological groups so that we could determine if groups would be represented at all burn severities. We found that while members of the same ecological groups shared foraging strategy and prey items, they did vary in response to burn severity, resulting in unique species assemblages with nearly all guilds represented at all burn severities. For example, aerial insectivores play an important role in the ecosystem by controlling insect populations. At all burn severities, including unburned sites, we observed high numbers of Western Wood-pewees. At moderately burned sites we observed higher abundances of Dusky Flycatchers and Townsend's Solitaires. At high burn severities, we observed higher abundance of Olive-sided Flycatchers and both Western and Mountain Bluebirds. At least one representative of the guild was successful at every burn severity. Similar patterns were observed for other avian groups, suggesting that most ecological roles, services, and function will be preserved in habitat that burns at any burn severity. While most small mammal groups exhibited similar patterns, tree squirrels did not. Tree squirrels, including Northern Flying Squirrels, Douglas Squirrel, and Western Gray Squirrels, were not well represented as an ecological group in high severity burns, even three years post-fire. Longer term monitoring of burned areas may determine if and how this group recovers from fires of high severity.

By understanding the most important habitat characteristics for re-colonization of wildlife, we may more effectively manage burned forests for conservation of biodiversity. We found that parameters of importance differed among birds and small mammals and between ecological groups. Groups that responded favorably to increasing burn severity were those that were able to exploit habitat features characteristic of burned areas. These characteristics include higher understory cover, higher density of snags, and higher density of arthropods (Ferrell, 1996; Bagne, et al., 2008). Snags in burned forests are likely to be invaded by bark and wood-boring beetles and population explosions of understory- and snag-associated insects are common after fire (Parker et al., 2006). Increases in insect populations are likely to be the reason for increases in aerial insectivore and bark foraging birds observed in this study in high severity burns (see also Martin et al., 2006). The nesting and denning habits of groups also influenced their ability to utilize habitat within the burned areas. Primary cavity nesting birds increased with burn severity, likely due to the availability of snags for nesting and foraging. Ecological groups that declined with increasing burn severity rely upon nesting and foraging substrates that are destroyed by fire. Foliage gleaning birds, chipmunks, and tree squirrels are negatively associated

with burn severity, and all rely upon the products of live trees: seeds, nuts, and insects associated with live foliage. For ecological groups such as chipmunks that rely upon dense understory and coarse woody debris for cover and foraging areas, fire may initially reduce available habitat and result in declines in abundance in the short term. A higher percentage of ground cover, particularly shrubs, was important for many small mammal groups. These features are characteristic of burned forest, suggesting that the fire created the habitat that is required for wildlife response. By the third year after fire, nearly all ecological groups responded favorably or neutrally to burn severity, indicating that even severely burned forest provides important and necessary habitat features.

Management Implications

Fire is a natural and regular disturbance in mixed conifer forests and may create snags, change forest structure and composition, and alter arthropod populations (Kotliar et al., 2002). There are species within nearly all taxa that respond positively to fire (Smith, 2000) and some species even appear largely to be restricted to burned areas (Hutto, 1995; Kotliar et al., 2002). Species richness is often not greatly affected by burn severity, although composition of species will change under different fire conditions. This suggests that fires help maintain the biological diversity of forests across landscapes. Biodiversity has been linked to ecosystem function and services (Hooper et al., 2005) resulting in increased interest and focus by mangers in maintaining richness to increase resilience. Results from this study may aid in the management of recently burned forests for multiple objectives, including the maintenance of biodiversity, a reduction in the risk of fire to human life and property, and a reduction in future fire risk.

Our inferences are limited by a number of factors: the number of sites with sequential years of sampling, time series limited to three years post-burn, and lack of pre-burn data at most sites. However, our results provide reliable and revealing insights into how wildlife are affected by burn severity, but are limited in adding to our understanding of the effects of post-fire treatments. The suite of sample sites this study created – 98 sites along a gradient of burn severity with 3 consecutive years of data collection – provides a valuable foundation for understanding the effects of future treatments. As treatments are implemented across the Angora fire footprint, it would be valuable to resample these sites to gain a more robust understanding of treatment effects. Additionally, it would be valuable for managers to understand how urbanization and treatment interact to affect wildlife communities. This study suggests that treatments in urban areas have minimal negative impacts on burn-specialists. As this is the area of primary concern in reducing risk of future fire and damage to human life and property, implementing PFH in these areas may allow managers to meet multiple goals of reducing risks and maintaining ecosystem function and biodiversity. Comparing community composition and biodiversity in urban/wildand/treated/untreated sites would determine if restricting treatments to urbanized areas or limiting treatments in wildland area is a viable option for managers of burned forests.

In the short term, birds seem to respond more favorably to post-fire forest conditions than small mammals, and ecological groups varied greatly in their response to burn severity and other habitat features. This suggests that multi-objective management goals that include biodiversity would ideally include fire management strategies that result in a patchy distribution of low,

moderate, and even high severity burns. This would require the development of fire management plans that include let-burn approaches and the use of prescribed fire as tools for landscape-scale forest management for long-term resilience. Such a plan would include a range of acceptable burn severities across a landscape. In addition to maintaining avian species diversity and populations of fire-adapted species, an integrated fire management strategy directed at creating a patchy and variable fire intensity will serve also to support small mammal diversity, with disturbance tolerant species such as mice immediately utilizing highly burned areas and more sensitive groups, like tree squirrels, utilizing less severely burned stands with remnant live trees. Heterogeneous habitat conditions created or maintained by fire, particularly in wildland areas, will likely provide the most valuable habitat for birds, small mammals, and ants.

Post-fire management commonly includes logging to remove trees, snags, and other biomass from burned areas (Lindenmayer and Noss, 2006). Treatment prescriptions typically call for the removal of most or all snags, leaving approximately 5-10 large snags per hectare for wildlife use. Reduction in snag density is likely to negatively affect groups with strong, positive associations with snag density. Birds diversity can be negatively impacted by post-fire treatment for many years after treatment (Saab, et al., 1998, 2007b, 2009; Hutto, 2006) in large part due to reductions in snag density and diversity. Our study suggests that small mammals are less dependent on snag density and are less likely to be negatively affected by post-fire snag removal than birds. Treatments that aim to reduce risk of damage to property or life created by dead, standing trees, are most effectively focused on the wildland-urban interface areas, and in these areas the impact of treatment on wildlife community recovery is lower because of lower habitat suitability in urban areas. Most species that we found in higher abundance in urban sites were not fire specialists, suggesting that limiting treatments in urban areas will reduce impact to fire-adapted and dependent species. For managers aiming to maintain biodiversity and ecosystem functionality, planning post-fire harvest treatments that leave stands of snags that differ in size, species, and density in wildlands will maintain habitat heterogeneity for wildlife communities (Hutto, 2006).

Ecosystem function and structure may also be maintained by focusing on potential keystone species, such as woodpeckers. Woodpeckers create cavities that are used by other species for denning, resting, roosting, and resting (Martin and Eadie, 1999; Tarbill, 2010). These cavities may facilitate the recovery of secondary cavity users, a group which includes several bird species, tree squirrels, chipmunks, and small avian and mammalian carnivores. Woodpecker abundance increased with the density of all sizes of snags, suggesting that managers aiming to preserve these keystone species and the community they support will need to maintain habitat with high densities of multi-sized snags.

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Appendices

Appendix A. Vegetation sampling methods

The plot grids were set up and the majority of data collected on vegetation and habitat characteristics were collected by the Region 5 Ecology Program and University of Montana for a SNPLMA-funded project.

General information

Elevation, slope, aspect, and UTM coordinates were recorded for each plot, as well as information on dominant plant/tree species, observed fire severity, and observer's comments.

Trees and Snags

Trees and snags over 11in DBH were surveyed in a fixed 5^{th}-acre plot, and additional trees and snags were included based on a 20 factor prism. Measurements including diameter at breast height, total height, and live crown base height were recorded for all trees, which were identified to species and assigned a crown class or, in the case of snags, decay class. Signs of wildlife use and tree damage were also recorded, along with an estimate of overall health. All trees and snags above breakpoint diameter were also tagged for use in further inventories.

Fuels

Fuels were sampled according to Brown's planar intercept method (Brown, 1974), using four 16-m transects. Coarse woody debris at least 8in in diameter at the smaller end was measured and divided into diameter classes. Methods described in Waddell (2002) were used to convert measurements into percent cover of coarse woody debris.

Vegetation Composition and Ground Cover

Live and dead herbs and shrubs were identified to species and recorded with ocular estimates of percent cover within 5^{th}-acre and 10^{th}-acre plots, along with estimates grouped by life form (tree, shrub, forb, or grass). In addition, twenty 0.5-m quadrats were sampled along the four fuels transects, and percent cover, nested-rooted frequency, and average height were recorded for each species within each quadrat.

Photos

Four photos were taken at each plot – two facing toward plot center from the distal ends of the North and South transects, and two facing along the East and West transects taken from plot center.

Appendix B. Equations used to calculate trap effort

Equation 1. Corrected trapping effort (trap nights)

$$Effort = n_{total} - n_{miss} + n_{dest} - .5(n_{spru} + n_{dist})$$

n= number of traps, miss=missing, dest=destroyed, spru=sprung, dist=disturbed
Effort calculated separately for AM and PM sessions, then weighted according to the average time interval between visits as follows:

$$Effort_{total} = .67\ Effort_{AM} + .33(Effort_{PM})$$

Equation 2. Small mammal abundance (individuals per 100 trap nights)

$$Abundance = 100 * \frac{Number\ of\ adult\ individuals}{Effort}$$

Appendix C. Frequency of species detected in and around Angora Fire.

Table C-1. Frequency of most common plant species detected at 98 sites in 2008-2010.

Common Name	Type	Scientific Name	Frequency
Spreading Groundsmoke	Forb	*Gayophytum diffusum*	52%
Prickly Lettuce	Forb	*Lactuca serriola*	28%
Common Yarrow	Forb	*Achillea millefolium*	18%
Tall Annual Willowherb	Forb	*Epilobium brachycarpum*	17%
Rose Thistle	Forb	*Cirsium andersonii*	16%
Squirreltail	Graminoid	*Elymus elymoides*	20%
Sedge	Graminoid	*Carex* spp.	19%
Needlegrass	Graminoid	*Achnatherum* spp.	15%
Ross' Sedge	Graminoid	*Carex rossii*	13%
Whitethorn Ceanothus	Shrub	*Ceanothus cordulatus*	70%
Greenleaf Manzanita	Shrub	*Arctostaphylos patula*	39%
Prostrate Ceanothus	Shrub	*Ceanothus prostratus*	25%
Creeping Snowberry	Shrub	*Symphoricarpos mollis*	22%
Antelope Bitterbrush	Shrub	*Purshia tridentata*	12%
Jeffrey Pine	Tree	*Pinus jeffreyi*	84%
White Fir	Tree	*Abies concolor*	75%
Lodgepole Pine	Tree	*Pinus contorta*	25%
Incense Cedar	Tree	*Calocedrus decurrens*	24%
Red Fir	Tree	*Abies magnifica*	21%
Sugar Pine	Tree	*Pinus lambertiana*	14%
Western White Pine	Tree	*Pinus monticola*	2%
Ponderosa Pine	Tree	*Pinus ponderosa*	1%
Mountain Hemlock	Tree	*Tsuga mertensiana*	1%

Table C-2. Frequency of bird species detected at 98 sites in 2008-2010, with ecological groups.

Common Name	Scientific Name	Code	Ecological group	Freq 2008 n=41	Freq 2009 n=66	Freq 2010 n=71
Steller's Jay	*Cyanocitta stelleri*	STJA	Ground omnivore	93%	94%	97%
Mountain Chickadee	*Poecile gambeli*	MOCH	Foliage gleaner	85%	92%	93%
American Robin	*Turdus migratorius*	AMRO	Ground insectivore	83%	94%	90%
Dark-eyed Junco	*Junco hyemalis*	DEJU	Ground granivore	83%	92%	89%
Western Wood-Pewee	*Contopus sordidulus*	WEWP	Aerial insectivore	76%	88%	87%
Brown-headed cowbird	*Molothrus ater*	BHCO	Ground granivore	76%	83%	83%
Western Tanager	*Piranga ludoviciana*	WETA	Foliage gleaner	76%	76%	55%
Hairy Woodpecker	*Picoides villosus*	HAWO	Bark forager	73%	64%	89%
Black-backed Woodpecker	*Picoides arcticus*	BBWO	Bark forager	61%	38%	45%
Red-breasted Nuthatch	*Sitta canadensis*	RBNU	Bark forager	59%	61%	54%
White-headed Woodpecker	*Picoides albolarvatus*	WHWO	Bark forager	51%	53%	49%
White-breasted Nuthatch	*Sitta carolinensis*	WBNU	Bark forager	49%	35%	55%
Northern Flicker	*Colaptes auratus*	NOFL	Ground insectivore	49%	27%	51%
Pygmy Nuthatch	*Sitta pygmaea*	PYNU	Bark forager	41%	39%	42%
Olive-sided Flycatcher	*Contopus cooperi*	OSFL	Aerial insectivore	39%	36%	34%
Townsend's Solitaire	*Myadestes townsendi*	TOSO	Aerial insectivore	34%	44%	32%
Brown Creeper	*Certhia americana*	BRCR	Bark forager	32%	76%	79%
House Wren	*Troglodytes aedon*	HOWR	Foliage gleaner	29%	52%	52%
Fox Sparrow	*Passerella iliaca*	FOSP	Ground insectivore	27%	44%	41%
Brewer's Blackbird	*Euphagus cyanocephalus*	BRBL	Ground granivore	27%	36%	30%
Dusky Flycatcher	*Empidonax oberholseri*	DUFL	Aerial insectivore	27%	33%	23%
Evening Grosbeak	*Coccothraustes vespertinus*	EVGR	Ground granivore	24%	32%	23%
Yellow-rumped Warbler	*Dendroica coronata*	YRWA	Foliage gleaner	22%	55%	66%
Black-headed Grosbeak	*Pheucticus melanocephalus*	BHGR	Ground insectivore	22%	14%	11%
Common Raven	*Corvus corax*	CORA	Ground omnivore	20%	6%	7%
Clark's Nutcracker	*Nucifraga columbiana*	CLNU	Foliage gleaner	17%	0%	10%
Mountain Quail	*Oreortyx pictus*	MOUQ	Ground granivore	15%	27%	11%
Mountain Bluebird	*Sialia currucoides*	MOBL	Aerial insectivore	15%	18%	28%

Common Name	Scientific Name	Code	Ecological group	Freq 2008 n=41	Freq 2009 n=66	Freq 2010 n=71
Nashville Warbler	*Vermivora ruficapilla*	NAWA	Foliage gleaner	15%	9%	0%
Cassin's Finch	*Carpodacus cassinii*	CAFI	Ground granivore	12%	29%	52%
Red Crossbill	*Loxia curvirostra*	RECR	Foliage gleaner	12%	5%	3%
Mallard	*Anas platyrhynchos*	MALL	Dabbler	10%	23%	23%
Song Sparrow	*Melospiza melodia*	SOSP	Ground insectivore	10%	18%	14%
Golden-crowned Kinglet	*Regulus satrapa*	GCKI	Foliage gleaner	10%	11%	11%
Hermit Thrush	*Catharus guttatus*	HETH	Ground insectivore	10%	3%	0%
Chipping Sparrow	*Spizella passerina*	CHSP	Ground granivore	7%	36%	28%
Pine Siskin	*Carduelis pinus*	PISI	Foliage gleaner	7%	18%	20%
Warbling Vireo	*Vireo gilvus*	WAVI	Foliage gleaner	7%	11%	7%
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL	Ground insectivore	7%	6%	14%
Downy Woodpecker	*Picoides pubescens*	DOWO	Bark forager	7%	5%	1%
Pileated Woodpecker	*Dryocopus pileatus*	PIWO	Bark forager	7%	2%	4%
Western Bluebird	*Sialia mexicana*	WEBL	Aerial insectivore	5%	18%	30%
House Finch	*Carpodacus mexicanus*	HOFI	Ground granivore	5%	17%	23%
Cassin's Vireo	*Vireo cassinii*	CAVI	Foliage gleaner	5%	11%	4%
White-crowned Sparrow	*Zonotrichia leucophrys*	WCSP	Ground insectivore	5%	3%	24%
Barn Swallow	*Hirundo rustica*	BARS	Aerial insectivore	5%	0%	1%
European Starling	*Sturnus vulgaris*	EUST	Ground insectivore	2%	11%	15%
Williamson's Sapsucker	*Sphyrapicus thyroideus*	WISA	Bark forager	2%	8%	3%
Wilson's Warbler	*Wilsonia pusilla*	WIWA	Foliage gleaner	2%	6%	17%
Band-tailed Pigeon	*Columba fasciata*	BTPI	Foliage gleaner	2%	6%	10%
Red-breasted Sapsucker	*Sphyrapicus ruber*	RBSA	Bark forager	2%	6%	7%
Cliff Swallow	*Petrochelidon pyrrhonota*	CLSW	Aerial insectivore	2%	5%	4%
Hermit Warbler	*Dendroica occidentalis*	HEWA	Foliage gleaner	2%	3%	0%
Mourning Dove	*Zenaida macroura*	MODO	Ground granivore	2%	2%	11%
Green-tailed Towhee	*Pipilo chlorurus*	GTTO	Ground granivore	2%	2%	10%
Red-tailed Hawk	*Buteo jamaicensis*	RTHA	Diurnal raptor	2%	2%	6%
Orange-crowned Warbler	*Vermivora celata*	OCWA	Foliage gleaner	2%	2%	1%
MacGillivray's Warbler	*Oporornis tolmiei*	MGWA	Foliage gleaner	2%	0%	1%
Great Horned Owl	*Bubo virginianus*	GHOW	Nocturnal raptor	2%	0%	1%
Anna's Hummingbird	*Calypte anna*	ANHU	Hoverer	2%	0%	0%

Common Name	Scientific Name	Code	Ecological group	Freq 2008 n=41	Freq 2009 n=66	Freq 2010 n=71
Cooper's Hawk	*Accipiter cooperii*	COHA	Diurnal raptor	2%	0%	0%
Lazuli Bunting	*Passerina amoena*	LAZB	Ground insectivore	0%	26%	4%
Lesser Goldfinch	*Carduelis psaltria*	LEGO	Foliage gleaner	0%	23%	13%
Rufous Hummingbird	*Selasphorus rufus*	RUHU	Hoverer	0%	15%	0%
Spotted Towhee	*Pipilo maculatus*	SPTO	Ground insectivore	0%	6%	1%
Tree Swallow	*Tachycineta bicolor*	TRES	Aerial insectivore	0%	5%	3%
California Quail	*Callipepla californica*	CAQU	Ground granivore	0%	3%	3%
Sharp-shinned Hawk	*Accipiter striatus*	SSHA	Diurnal raptor	0%	3%	0%
Common Nighthawk	*Chordeiles minor*	CONI	Aerial insectivore	0%	3%	0%
Killdeer	*Charadrius vociferus*	KILL	Ground insectivore	0%	2%	3%
Sooty Grouse	*Dendragapus fuliginosus*	SOGR	Ground herbivore	0%	2%	1%
Bullock's Oriole	*Icterus bullockii*	BUOR	Hoverer	0%	2%	0%
Calliope Hummingbird	*Stellula calliope*	CAHU	Hoverer	0%	2%	0%
Indigo Bunting	*Passerina cyanea*	INBU	Foliage gleaner	0%	2%	0%
Savannah Sparrow	*Passerculus sandwichensis*	SAVS	Ground insectivore	0%	2%	0%
Spotted Sandpiper	*Actitis macularia*	SPSA	Ground insectivore	0%	0%	7%
Lincoln's Sparrow	*Melospiza lincolnii*	LISP	Ground insectivore	0%	0%	3%
Rock wren	*Salpinctes obsoletus*	ROWR	Ground insectivore	0%	0%	1%
Wilson's Snipe	*Gallinago delicata*	WISN	Probe forager	0%	0%	1%
Pacific-slope Flycatcher	*Empidonax difficilis*	PSFL	Aerial insectivore	0%	0%	1%

Table C-3. Frequency of small mammal species detected at 69 study sites in 2008-2010, with ecological group.

Common name	Scientific name	Code	Ecological group	2008 Freq n=30	2009 Freq n=44	2010 Freq n=39
Deer Mouse	*Peromyscus maniculatus*	PEMA	Mouse	83%	100%	92%
California Ground Squirrel	*Spermophilus beechyi*	SPBE	Ground squirrel	83%	86%	82%
Yellow-pine Chipmunk	*Tamias amoenus*	TAAM	Chipmunk	63%	89%	97%
Long-eared Chipmunk	*Tamias quadrimaculatus*	TAQU	Chipmunk	47%	91%	87%
Allen's Chipmunk	*Tamias senex*	TASE	Chipmunk	40%	75%	51%
Golden-mantled Ground Squirrel	*Spermophilus lateralis*	SPLA	Ground squirrel	37%	43%	36%
Lodgepole Chipmunk	*Tamias speciosus*	TASP	Chipmunk	37%	43%	15%
Douglas' Squirrel	*Tamiasciurus douglasii*	TADO	Tree squirrel	23%	23%	46%
Northern Flying Squirrel	*Glaucomys sabrinus*	GLSA	Tree squirrel	17%	20%	13%
Long-tailed Vole	*Microtus longicaudus*	MILO	Vole	13%	34%	51%
Montane Vole	*Microtus montanus*	MIMO	Vole	7%	27%	41%
Pinyon Mouse	*Peromyscus truei*	PETR	Mouse	0%	5%	0%
Trowbridge's Shrew	*Sorex trowbridgii*	SOTR	Shrew	0%	5%	0%
Vagrant Shrew	*Sorex vagrans*	SOVA	Shrew	0%	2%	0%
Western Gray Squirrel	*Sciurus griseus*	SCGR	Tree squirrel	0%	0%	5%
Least Chipmunk	*Tamias minimus*	TAMI	Chipmunk	0%	0%	3%
Botta's Pocket Gopher	*Thomomys bottae*	THBO	Gopher	0%	0%	3%

Table C-4. Frequency of ant species detected at 40 study sites in 2008.

Species	Frequency	Ecological Group	Species	Frequency	Ecological Group
Formica cf sibylla	93%	Aerator	*Camponotus laevigatus*	18%	Decomposer
Camponotus vicinus	88%	Generalist	*Formica neogagates*	13%	Generalist
Formica fusca	85%	Aerator	*Manica bradleyi*	13%	Generalist
Formica microphthalma	70%	Generalist	*Formica obscuripes*	10%	Compiler
Formica sibylla	68%	Aerator	*Myrmica americana*	10%	Generalist
Myrmica tahoensis	65%	Aerator	*Temnothorax nevadensis*	10%	Aerator
Formica lasioides	53%	Aerator	*Temnothorax rugatulus*	10%	Generalist
Aphaenogaster occidentalis	50%	Generalist	*Lasius sitiens*	8%	Generalist
Formica aserva	45%	Decomposer	*Manica invidia*	8%	Generalist
Camponotus modoc	43%	Decomposer	*Myrmica discontinua*	8%	Generalist
Formica argentea	43%	Aerator	*Polyergus breviceps*	8%	Generalist
Lasius pallitarsis	23%	Generalist	*Formica ravida*	5%	Compiler
Formica neorufibarbis	20%	Generalist	*Lasius humilis*	5%	Generalist
Tapinoma sessile	20%	Generalist	*Formica accreta*	3%	Decomposer
			Formica neoclara	3%	Generalist
			Lasius nevadensis	3%	Generalist

Appendix D. Explanatory variables and transformation procedures for regression analysis

Table D-1. Explanatory variables and transformations used in regression analyses. Variables generally did not meet assumptions of normality in raw state.

Variable	Description	Radius	Units	Transformation
Burn Severity [1]	Average differenced-normalized burn ratio (DNBR)[2]	100m	%	Arcsine square root
Impervious Surfaces [1]	Percent cover of roads, trails, and buildings	100m	%	Arcsine square root
High-Elevation Conifer [1]	Percent cover of High-elevation conifer vegetation	100m	%	Arcsine square root
Total Conifer [1]	Percent cover of low and high-elevation conifer vegetation	100m	%	Arcsine square root
ShrubGIS [1]	Percent cover of shrub vegetation	100m	%	Arcsine square root
WetlandGIS [1]	Percent cover of riparian and meadow vegetation	100m	%	Arcsine square root
Trees: small, medium, large, total	Density of live trees; small 11-24in, medium 24-36in, large >36in DBH, total all sizes	16m	stems/ha	Natural Log
Snags: small, medium, large, total	Density of dead, standing trees; small 11-24in, medium 24-36in, large >36in DBH, total all sizes	16m	stems/ha	Natural Log
CWD: small, large	% cover of coarse woody debris; small <12in, large >12in, total all sizes	16m	%	Arcsine square root
Herb Cover	% cover of herbaceous and graminoid plants	16m	%	Arcsine square root
Shrub Cover	% cover of woody shrubs	16m	%	Arcsine square root

[1]: Generated from Landsat and IKONOS satellite imagery using ArcGIS 9.3 2003
[2]: As described in Salvador et al., 2000.

Table D-2. Procedure used to modify outlying values in explanatory variables prior to regression analysis.

Equation only applied when 1 or 2 values were greater than $x + 3SD_x$

1 outlier: with values in ascending order from x_1 to x_n

$$Mod(x_n) = x_{n-1} + \frac{x_{n-1} - x_{n-2} + x_{n-2} - x_{n-3}}{2}$$

2 or more outliers: with values in ascending order from x_1 to x_n

$$Mod(x_{n-1}) = x_{n-2} + \frac{x_{n-2} - x_{n-3} + x_{n-3} - x_{n-4}}{2}$$

$$Mod(x_n) = Mod(x_{n-1}) + (x_n - x_{n-1})$$

Appendix E. Results of Multiple Regression for Bird Community

Table E-1. Top models of bird response. Tables include all models with ΔAIC_c <2, and only those variables accounting for 50% of the summed importance are included in model-averaged coefficients tables. Asterisks indicate parameter estimates with 95% confidence intervals that do not include zero and therefore are statistically significant. No more than seven explanatory variables were included in a single model.

Abundance of bark foragers						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
SmSnag MedTree TotalConifer ShrubGIS Wetland Burn	0.00	0.05	Intercept	1.00	0.00	0.08
SmSnag MedTree Impervious TotalConifer Burn	0.12	0.05	SmSnag*	1.00	0.34	0.11
SmSnag SmTree MedTree TotalConifer ShrubGIS Wetland Burn	0.27	0.04	TotalConifer	0.95	0.40	0.26
SmSnag SmTree TotalConifer ShrubGIS Wetland Burn	0.52	0.04	MedTree	0.72	0.20	0.10
SmSnag SmTree MedTree Impervious TotalConifer Burn	0.75	0.03	Burn	0.63	0.23	0.13
SmSnag MedTree Impervious TotalConifer	0.89	0.03				
SmSnag MedTree TotalConifer ShrubGIS Wetland	1.16	0.03				
SmSnag TotalConifer ShrubGIS Wetland	1.42	0.02				
SmSnag MedTree LgTree TotalConifer ShrubGIS Wetland Burn	1.44	0.02				
SmSnag MedTree TotalConifer ShrubGIS Burn	1.52	0.02				
SmSnag SmTree Impervious TotalConifer Burn	1.55	0.02				
SmSnag MedTree TotalConifer ShrubGIS	1.62	0.02				
SmSnag MedTree TotalConifer Burn	1.62	0.02				
SmSnag MedTree Herb TotalConifer ShrubGIS Wetland Burn	1.65	0.02				
SmSnag TotalConifer ShrubGIS	1.66	0.02				
SmSnag MedSnag MedTree TotalConifer ShrubGIS Wetland Burn	1.72	0.02				
SmSnag Impervious TotalConifer	1.76	0.02				
SmSnag SmTree Shrub TotalConifer ShrubGIS Wetland Burn	1.77	0.02				
SmSnag TotalConifer	1.80	0.02				
SmSnag MedSnag MedTree Impervious TotalConifer Burn	1.81	0.02				
SmSnag MedSnag SmTree TotalConifer ShrubGIS Wetland Burn	1.82	0.02				
SmSnag MedTree Impervious TotalConifer ShrubGIS Wetland Burn	1.83	0.02				
SmSnag MedTree TotalConifer	1.93	0.02				

Abundance of aerial insectivores						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
MedSnag LgSnag SmTree MedTree Impervious Burn	0.00	0.06	Intercept	1.00	0.00	0.08
MedSnag LgSnag SmTree MedTree CWDSm Impervious Burn	0.10	0.06	Burn*	1.00	0.35	0.12
MedSnag LgSnag Impervious Burn	0.93	0.04	MedSnag*	0.99	0.30	0.10
MedSnag LgSnag CWDSm Impervious Burn	1.27	0.03	LgSnag*	0.92	-0.22	0.10
MedSnag LgSnag SmTree MedTree CWDLg Impervious Burn	1.29	0.03	Impervious*	0.66	-0.19	0.10
MedSnag LgSnag SmTree CWDSm Impervious Burn	1.48	0.03	SmTree	0.53	-0.23	0.13
MedSnag LgSnag MedTree Impervious Burn	1.54	0.03	MedTree	0.50	0.19	0.11
MedSnag LgSnag CWDLg CWDSm Impervious Burn	1.59	0.03				
MedSnag LgSnag SmTree MedTree Herb Impervious Burn	1.59	0.03				
MedSnag LgSnag SmTree Impervious Burn	1.66	0.03				
MedSnag LgSnag SmTree CWDLg CWDSm Impervious Burn	1.69	0.03				
MedSnag LgSnag SmTree MedTree Impervious HighElevConifer Burn	1.80	0.03				
MedSnag LgSnag SmTree MedTree HighElevConifer Burn	1.82	0.02				
MedSnag LgSnag HighElevConifer Burn	1.82	0.02				
MedSnag LgSnag SmTree MedTree LgTree Impervious Burn	1.94	0.02				

Abundance of ground omnivores						
	Top models		Model-averaged coefficients			
Model	ΔAIC_c	w_i	Variable	$\sum w_i$	β	± SE
SmallSnag SmallTree Herb TotalConifer	0.00	0.06	Intercept	1.00	2.95	7.73
SmallSnag SmallTree Herb	0.02	0.06	Herb*	0.95	0.23	0.09
SmallSnag SmallTree Herb WetlandGIS	0.57	0.04	SmallSnag*	0.87	-0.24	0.11
SmallSnag SmallTree Herb ShrubGIS	0.75	0.04	SmallTree*	0.66	0.24	0.11
SmallSnag SmallTree Herb ShrubGIS WetlandGIS	1.25	0.03				
Burn SmallSnag Herb TotalConifer	1.33	0.03				
Burn SmallSnag Herb ShrubGIS WetlandGIS	1.42	0.03				
SmallSnag SmallTree CWDSm Herb TotalConifer	1.43	0.03				
SmallSnag MedSnag SmallTree Herb	1.54	0.03				
Burn SmallSnag Herb WetlandGIS	1.58	0.03				
SmallSnag SmallTree Herb TotalConifer WetlandGIS	1.68	0.02				
Burn SmallSnag SmallTree Herb TotalConifer	1.71	0.02				
SmallSnag SmallTree CWDSm Herb	1.81	0.02				
Burn SmallSnag CWDSm Herb TotalConifer	1.84	0.02				
SmallSnag MedSnag SmallTree Herb TotalConifer	1.86	0.02				

Abundance of ground granivores						
	Top models		Model-averaged coefficients			
Model	ΔAIC_c	w_i	Variable	$\sum w_i$	β	± SE
Year CWDLg Herb TotalConifer ShrubGIS	0.00	0.08	Intercept	1.00	-788.02	230.21
Year LargeSnag CWDLg Herb HighElevConifer TotalConifer ShrubGIS	0.24	0.07	Year*	1.00	0.39	0.11
Year SmallSnag CWDLg Herb TotalConifer ShrubGIS	0.61	0.06	ShrubGIS*	0.99	-0.69	0.15
Year CWDLg Herb Shrub TotalConifer ShrubGIS	0.77	0.06	TotalConifer*	0.99	-0.67	0.16
Year SmallSnag LargeSnag CWDLg Herb TotalConifer ShrubGIS	0.83	0.05	CWDLg*	0.96	-0.21	0.08
Year CWDLg Herb HighElevConifer TotalConifer ShrubGIS	0.87	0.05	Herb*	0.88	0.20	0.08
Year LargeSnag CWDLg Herb TotalConifer ShrubGIS	0.94	0.05				
Year CWDLg Herb TotalConifer ShrubGIS WetlandGIS	1.13	0.05				
Year CWDLg Herb Shrub TotalConifer ShrubGIS WetlandGIS	1.38	0.04				
Year SmallSnag CWDLg Herb TotalConifer ShrubGIS WetlandGIS	1.45	0.04				
Year CWDLg Herb HighElevConifer TotalConifer ShrubGIS WetlandGIS	1.61	0.04				
Year LargeSnag CWDLg HighElevConifer TotalConifer ShrubGIS WetlandGIS	1.77	0.03				
Year LargeSnag CWDLg HighElevConifer TotalConifer ShrubGIS	1.84	0.03				
Year LargeSnag CWDLg Herb Shrub TotalConifer ShrubGIS	1.86	0.03				
Year SmallTree CWDLg Herb HighElevConifer TotalConifer ShrubGIS	1.90	0.03				
Year SmallSnag CWDLg Herb Shrub TotalConifer ShrubGIS	1.90	0.03				
Year CWDLg Herb Impervious TotalConifer ShrubGIS	1.94	0.03				
Year SmallTree CWDLg Herb TotalConifer ShrubGIS	1.94	0.03				
Year MedSnag CWDLg Herb TotalConifer ShrubGIS	2.00	0.03				

Abundance of ground insectivores						
	Top models		Model-averaged coefficients			
Model	ΔAIC$_c$	w_i	Variable	$\sum w_i$	β	± SE
Burn SmallSnag SmallTree Herb	0.00	0.06	Intercept	1.00	-16.73	38.10
Burn SmallTree Herb Impervious	0.76	0.04	Herb*	1.00	0.43	0.09
Burn SmallSnag SmallTree Herb Shrub	0.78	0.04	SmallTree*	0.90	-0.35	0.14
Burn SmallSnag SmallTree Herb Impervious	1.08	0.03	Burn*	0.81	-0.33	0.14
Burn SmallSnag LargeSnag SmallTree Herb	1.17	0.03	SmallSnag	0.74	-0.21	0.11
Burn SmallSnag SmallTree LargeTree Herb	1.18	0.03				
Burn SmallSnag SmallTree CWDSm Herb	1.38	0.03				
Burn SmallSnag MedSnag SmallTree Herb	1.57	0.03				
SmallSnag SmallTree Herb	1.58	0.03				
Burn SmallTree Herb Shrub Impervious	1.64	0.03				
Burn SmallSnag SmallTree LargeTree Herb Shrub	1.72	0.03				
Burn LargeSnag SmallTree Herb Impervious	1.74	0.02				
Burn SmallTree LargeTree Herb Impervious	1.74	0.02				
Burn SmallSnag LargeSnag SmallTree Herb Impervious	1.82	0.02				
Burn SmallTree CWDSm Herb Shrub	1.84	0.02				
Burn SmallTree Herb Shrub	1.95	0.02				
Burn SmallSnag SmallTree CWDSm Herb Shrub	1.99	0.02				

Abundance of foliage gleaners						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
SmSnag MedTree CWDLg TotalConifer Wetland Burn	0.00	0.09	Intercept	1.00	-9.17	25.43
SmSnag MedTree CWDLg TotalConifer ShrubGIS Wetland Burn	0.02	0.09	Burn*	1.00	-0.48	0.10
SmSnag MedTree CWDLg Wetland Burn	0.61	0.07	SmSnag*	1.00	0.30	0.09
SmSnag MedTree CWDLg Shrub TotalConifer Wetland Burn	1.27	0.05	CWDLg*	1.00	0.29	0.08
SmSnag MedTree CWDLg Shrub Wetland Burn	1.62	0.04	MedTree*	0.96	0.23	0.09
SmSnag MedTree CWDLg Burn	1.73	0.04	Wetland*	0.78	0.19	0.10
Year SmSnag MedTree CWDLg TotalConifer Wetland Burn	1.87	0.04				
SmSnag MedTree CWDLg CWDSm TotalConifer Wetland Burn	1.89	0.03				
SmSnag MedTree CWDLg Impervious TotalConifer Wetland Burn	1.90	0.03				

	Total abundance of birds					
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
Year MedTree Herb TotalConifer Wetland	0.00	0.07	Intercept	1.00	-477.36	274.11
Year MedTree Herb ShrubGIS Wetland	0.20	0.06	Herb*	0.99	0.27	0.10
Year Herb TotalConifer Wetland Burn	0.97	0.04	Year*	0.89	0.27	0.12
Year MedTree CWDLg Herb ShrubGIS Wetland	1.24	0.04	Wetland*	0.84	0.24	0.11
Year MedTree Herb TotalConifer Wetland Burn	1.26	0.04	MedTree	0.68	0.19	0.10
Year Herb ShrubGIS Wetland Burn	1.31	0.04	ShrubGIS*	0.52	-0.21	0.10
Year Herb ShrubGIS Burn	1.43	0.03				
Year MedTree CWDLg Herb TotalConifer Wetland	1.55	0.03				
Year SmTree Herb TotalConifer Wetland	1.57	0.03				
Year SmTree Herb ShrubGIS Wetland	1.70	0.03				
Year MedTree Herb ShrubGIS Wetland Burn	1.72	0.03				
Year SmTree MedTree Herb TotalConifer Wetland	1.83	0.03				

	Species richness of birds					
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
Year MedTree TotalConifer Wetland Burn	0.00	0.09	Intercept	1.00	-601.72	246.09
Year SmTree MedTree TotalConifer Wetland Burn	0.44	0.07	Wetland*	1.00	0.44	0.11
Year LgSnag MedTree TotalConifer Wetland Burn	0.91	0.06	Burn*	1.00	0.47	0.13
Year SmSnag MedTree TotalConifer Wetland Burn	1.24	0.05	MedTree*	0.97	0.29	0.11
Year LgSnag SmTree MedTree TotalConifer Wetland Burn	1.71	0.04	Year*	0.96	0.31	0.12
Year MedTree Impervious TotalConifer Wetland Burn	1.81	0.04	TotalConifer	0.76	0.22	0.12
Year MedTree Shrub TotalConifer Wetland Burn	1.93	0.03				
Year SmSnag MedTree Wetland Burn	1.97	0.03				
Year MedTree LgTree TotalConifer Wetland Burn	1.97	0.03				
Year SmSnag LgSnag MedTree TotalConifer Wetland Burn	1.97	0.03				

Table E-2. Influence of explanatory variables on bird community response based on data collected in and around the Angora burn in 2008-2010. **Bold** symbols indicate >50% importance; zero indicates that the variable was not included in any model.

Parameter	**Bark forager**	**Aerial insectivore**	**Ground omnivore**	**Ground granivore**	**Ground insectivore**	**Foliage gleaner**	**Total Abundance**	**Species richness**
Burn	+	+	-	0	-	-	-	+
CWD large	0	+	+	-	0	+	+	+
CWD small	-	-	-	-	-	+	-	0
Herb	-	+	+	+	+	-	+	+
High Elevation Conifer	+	+	-	-	+	-	-	-
Impervious	-	-	+	+	+	-	+	+
Shrub	+	+	+	-	-	+	0	-
ShrubGIS	+	-	-	+	0	+	-	+
Snag density-large	+	-	+	+	+	-	0	-
Snag density-medium	+	+	+	-	-	+	+	+
Snag density-small	+	+	-	-	-	+	+	+
Total conifer	+	+	+	-	-	+	+	+
Tree density- large	-	+	-	0	-	-	-	+
Tree density-medium	+	+	+	-	-	+	+	+
Tree density-small	+	-	+	-	-	+	+	+
WetlandGIS	+	+	-	+	+	+	+	+
Year	0	0	-	-	+	+	+	+

Appendix F. Results of multiple regression for small mammal community

Table F-1. Top models of small mammal response. Tables include all models with ΔAIC_c <2, and only those variables accounting for 50% of the summed importance are included in model-averaged coefficients tables. Asterisks indicate parameter estimates with 95% confidence intervals that do not include zero and therefore are statistically significant. A maximum of four explanatory variables were included in a single model.

	Abundance of chipmunks					
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
Year Shrub ShrubGIS Burn	0.00	0.35	Intercept	1.00	-1006.44	260.58
Year Totaltree Shrub TotalConifer	1.34	0.18	Year*	1.00	0.50	0.13
			Shrub*	0.74	0.26	0.10
			ShrubGIS*	0.70	0.35	0.10
			Burn*	0.60	-0.32	0.10

	Abundance of tree squirrels					
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
WetlandGIS Burn	0.00	0.10	Intercept	1.00	-50.64	105.95
Totalsnag WetlandGIS Burn	0.69	0.07	Burn*	0.99	-0.46	0.12
Burn	1.20	0.05	WetlandGIS*	0.77	-0.22	0.11
Year WetlandGIS Burn	1.31	0.05				
Herb WetlandGIS Burn	1.40	0.05				
Year Totalsnag WetlandGIS Burn	1.41	0.05				
HighElevConifer WetlandGIS Burn	1.84	0.04				
CWDSm WetlandGIS Burn	1.95	0.04				

Abundance of ground squirrels

Model	Top models ΔAICc	wi	Model-averaged coefficients Variable	∑ wi	β	± SE
Year Herb TotalConifer	0.00	0.05	Intercept	1.00	-161.73	257.54
Herb TotalConifer	0.08	0.05	Herb	0.61	-0.21	0.12
WetlandGIS	0.22	0.04	TotalConifer	0.53	0.21	0.13
TotalConifer	0.44	0.04				
Herb	0.55	0.04				
Herb Shrub	0.76	0.03				
Year WetlandGIS	1.02	0.03				
Herb Shrub TotalConifer	1.05	0.03				
Year Totaltree Herb TotalConifer	1.09	0.03				
Totaltree Herb Shrub	1.11	0.03				
Herb WetlandGIS	1.21	0.03				
Totaltree Herb Shrub TotalConifer	1.26	0.03				
TotalConifer WetlandGIS	1.28	0.03				
Totaltree Herb TotalConifer	1.39	0.03				
Year Herb	1.44	0.02				
Totaltree TotalConifer	1.45	0.02				
Totaltree WetlandGIS	1.47	0.02				
Year Herb WetlandGIS	1.47	0.02				
Shrub WetlandGIS	1.47	0.02				
Year CWDSm Herb TotalConifer	1.52	0.02				
Year TotalConifer	1.52	0.02				
Year Herb TotalConifer WetlandGIS	1.56	0.02				
Herb Shrub WetlandGIS	1.57	0.02				
Totaltree Shrub WetlandGIS	1.72	0.02				
Year Herb Shrub TotalConifer	1.77	0.02				
CWDSm Herb TotalConifer	1.78	0.02				
Year Herb HighElevConifer TotalConifer	1.78	0.02				
Year TotalConifer WetlandGIS	1.79	0.02				
Totaltree Herb Shrub WetlandGIS	1.79	0.02				
Year Totalsnag Herb TotalConifer	1.87	0.02				
Herb TotalConifer WetlandGIS	1.90	0.02				
Year Herb TotalConifer ShrubGIS	1.96	0.02				

Abundance of mice						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
Year CWDLg Burn	0.00	0.11	Intercept	1.00	-354.34	332.48
CWDLg Burn	0.94	0.07	Burn*	0.99	0.40	0.13
Year Totaltree CWDLg Burn	1.38	0.05	CWDLg*	0.74	0.22	0.11
Year CWDLg Shrub Burn	1.45	0.05	Year	0.68	0.26	0.14
Year CWDLg CWDSm Burn	1.73	0.05				
Year CWDLg Imperv Burn	1.84	0.04				
Year CWDLg WetlandGIS Burn	1.91	0.04				

Abundance of voles						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
Year Herb	0.00	0.12	Intercept	1.00	-668.40	336.06
Year Herb HighElevConifer	1.45	0.06	Year*	0.92	0.36	0.15
Year Herb TotalConifer	1.52	0.05	Herb*	0.91	0.27	0.12
Year Herb Imperv	1.69	0.05				
Year CWDSm Herb	1.70	0.05				
Year Totaltree Herb	1.97	0.04				

Total abundance of small mammals						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
Year ShrubGIS	0.00	0.09	Intercept	1.00	-1329.15	267.20
Year Herb ShrubGIS	0.84	0.06	Year*	1.00	0.66	0.13
Year Totaltree ShrubGIS	0.91	0.05	ShrubGIS*	0.77	0.20	0.10
Year Totaltree Shrub ShrubGIS	0.95	0.05				
Year Totaltree CWDSm ShrubGIS	1.10	0.05				
Year Shrub ShrubGIS	1.25	0.05				
Year Herb Shrub ShrubGIS	1.37	0.04				
Year CWDSm ShrubGIS	1.44	0.04				
Year CWDLg ShrubGIS	1.47	0.04				
Year	1.67	0.04				
Year Herb	1.81	0.03				
Year ShrubGIS Burn	1.91	0.03				
Year Totaltree Herb ShrubGIS	1.97	0.03				

Species richness of small mammals						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
Year WetlandGIS Burn	0.00	0.08	Intercept	1.00	-747.58	343.78
Year Totaltree WetlandGIS	0.37	0.07	Year*	0.92	0.40	0.15
Year Shrub WetlandGIS Burn	0.39	0.07	Burn*	0.51	-0.27	0.12
Year Totaltree Shrub WetlandGIS	0.44	0.06	WetlandGIS	0.50	-0.22	0.11
Year CWDLg WetlandGIS Burn	0.54	0.06				
Year Totaltree	1.02	0.05				
CWDLg Shrub ShrubGIS Burn	1.02	0.05				
Year Totaltree Shrub	1.15	0.05				
Year ShrubGIS WetlandGIS Burn	1.16	0.04				
Year Totaltree CWDLg WetlandGIS	1.25	0.04				
Year Totaltree CWDLg Shrub	1.45	0.04				
Year Burn	1.73	0.03				
Year Totaltree CWDLg	1.75	0.03				
Year TotalConifer WetlandGIS Burn	1.99	0.03				

Table F-2. Influence of most important variables to small mammal response based on data collected in and around Angora fire in 2008-2010. **Bold** symbols indicate >50% importance; zero indicates that the variable was not included in any model.

Parameter	Chipmunks	Tree squirrels	Ground squirrels	Mice	Voles	Total abundance	Species richness
Burn	-	-	-	+	+	+	-
CWD large	-	+	0	+	0	+	+
CWD small	+	-	-	+	+	+	+
Herb	-	+	-	-	+	-	+
High elevation conifer	-	-	-	+	-	+	-
Impervious	-	-	-	+	+	-	+
Shrub	+	+	+	-	-	+	+
ShrubGIS	+	-	+	+	-	+	+
Total conifer	-	+	+	+	-	-	-
Snag density total	-	-	-	+	-	-	-
Tree density total	+	+	+	+	-	+	+
WetlandGIS	+	-	-	-	-	+	-
Year	+	+	+	+	+	+	+

Appendix G. Results of multiple regression for ant community

Table G-1. Top models tables include all models with ΔAIC_c <2, and only those variables accounting for 50% of the summed importance are included in model-averaged coefficients tables. Asterisks indicate parameter estimates with 95% confidence intervals that do not include zero and therefore are statistically significant. A maximum of four explanatory variables were included in a single model.

Abundance of aerators						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
TotalTree TotalSnag Burn	0.00	0.08	Intercept	1.00	180.38	31.55
CWDSm	0.43	0.07	CWDSm*	0.70	-77.33	30.28
TotalTree TotalSnag CWDSm Burn	0.48	0.06	TotalSnag*	0.54	-75.44	38.22
CWDSm ShrubGIS	0.66	0.06				
TotalSnag CWDSm	1.09	0.05				
TotalSnag CWDSm ShrubGIS	1.29	0.04				
TotalTree TotalSnag ShrubGIS Burn	1.36	0.04				
TotalSnag CWDSm TotalConifer ShrubGIS	1.56	0.04				
TotalTree TotalSnag Impervious Burn	1.91	0.03				
CWDSm Wetland	1.92	0.03				

Abundance of compilers						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
CWDLg Wetland	0.00	0.14	Intercept	1.00	30.66	13.30
Wetland	1.15	0.08	Wetland*	1.00	61.29	10.98
			CWDLg	0.67	30.78	16.21

Abundance of decomposers						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
Burn	0.00	0.08	Intercept	1.00	20.77	9.08
TotalSnag CWDLg Burn	0.23	0.07	Burn*	0.99	-32.86	9.52
CWDLg TotalConifer Burn	0.45	0.06				
TotalSnag Burn	0.70	0.06				
TotalConifer Burn	0.84	0.05				
TotalSnag CWDLg ShrubGIS Burn	0.98	0.05				
CWDLg Burn	0.99	0.05				
TotalSnag CWDLg TotalConifer Burn	1.30	0.04				
ShrubGIS Burn	1.45	0.04				
Wetland Burn	1.62	0.04				
CWDLg ShrubGIS Burn	1.94	0.03				

Abundance of generalists						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
TotalTree Burn	0.00	0.06	Intercept	1.00	47.85	7.80
CWDSm	0.13	0.06	Burn	0.54	20.82	12.49
Burn	0.48	0.05				
CWDLg	0.75	0.04				
CWDSm Burn	0.76	0.04				
Wetland	1.04	0.04				
TotalTree TotalSnag Burn	1.07	0.04				
Herb	1.14	0.04				
TotalTree CWDLg Burn	1.36	0.03				
HighElevConifer	1.39	0.03				
Impervious	1.51	0.03				
TotalTree	1.54	0.03				
TotalConifer	1.60	0.03				
TotalSnag	1.62	0.03				
CWDSm Herb	1.70	0.03				
CWDSm Wetland	1.70	0.03				
TotalTree Impervious Burn	1.72	0.03				
TotalTree HighElevConifer Burn	1.72	0.03				
CWDLg CWDSm	1.80	0.03				
TotalTree CWDSm Burn	1.83	0.03				
HighElevConifer Burn	1.94	0.02				

Total abundance of ants						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
CWDSm	0.00	0.08	Intercept	1.00	276.22	33.40
TotalTree CWDSm	0.09	0.08	CWDSm*	0.87	-80.83	35.05
TotalTree TotalSnag CWDSm	0.89	0.05	TotalTree	0.62	71.80	45.57
TotalSnag CWDSm	0.99	0.05				
CWDSm HighElevConifer	1.00	0.05				
TotalTree TotalSnag Burn	1.47	0.04				
CWDSm Herb	1.61	0.04				
TotalTree CWDSm TotalConifer	1.69	0.03				
CWDSm ShrubGIS	1.69	0.03				
CWDSm TotalConifer	1.75	0.03				
TotalTree TotalSnag CWDSm Burn	1.79	0.03				
CWDSm Wetland	1.86	0.03				
TotalTree CWDSm HighElevConifer	1.86	0.03				
TotalTree CWDSm Herb	1.93	0.03				

Species richness of ants						
	Top models		Model-averaged coefficients			
Model	ΔAICc	wi	Variable	∑ wi	β	± SE
CWDSm Impervious	0.00	0.08	Intercept	1.00	8.51	0.37
Impervious	0.39	0.07	Impervious*	0.99	1.28	0.36
CWDSm Herb Impervious	0.73	0.06	CWDSm	0.61	-0.61	0.34
CWDSm Shrub Impervious	0.92	0.05				
Impervious HighElevConifer	1.19	0.04				
CWDSm Impervious Burn	1.21	0.04				
CWDSm Impervious HighElevConifer	1.31	0.04				
CWDSm Impervious HighElevConifer Burn	1.52	0.04				
Shrub Impervious	1.65	0.04				
Herb Impervious	1.71	0.03				
CWDSm Impervious Wetland	1.89	0.03				
Impervious HighElevConifer Burn	1.92	0.03				

Table G-2. Influence of most important variables to ant response based on data collected in and around Angora fire. **Bold** symbols indicate >50% importance; zero indicates that the variable was not included in any model.

Parameter	Aerators	Compilers	Decomposers	Generalists	Total abundance	Species richness
Burn	+	-	-	**+**	+	+
CWD large	-	**+**	-	-	-	-
CWD small	**-**	+	**-**	-	-	-
Herb	+	+	-	+	+	+
High elevation conifer	-	-	**+**	-	-	-
Impervious	-	-	**-**	+	-	+
Shrub	+	-	-	+	+	+
ShrubGIS	+	+	-	-	+	+
Snag density total	**-**	+	+	-	-	-
Total conifer	+	-	+	+	-	-
Tree density total	+	+	-	+	**+**	-
WetlandGIS	-	**+**	-	-	+	+